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AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XXXI.—*The Æolian Sandstones of Fernando de Noronha;* by JOHN C. BRANNER.

BESIDES the rocks of igneous origin which make up the great body of the island of Fernando de Noronha* and its outliers, there is a sandstone covering about one-third of Ilha Rapta, part of São José, and small areas of the main island near the Lancha on the northeast, the high shore east of Atalaia Grande, that along the southwest side of the Sueste Bay, and forming all the exposed parts of Ilha Raza, Ilha do Meio, and the Chapeo at the mouth of Bahia do Sueste. Though these rocks make up but a small part of the island, and are but the remnants of their former extension, they afford some interesting facts in the island's history. No good fossils were found in them, but there is an abundance of fragments of shells, corals and other calcareous skeletons, all of organisms now living about the shores of the island, showing the rocks to be of recent origin.

In an article by Rev. T. S. Lea, published in the Proceedings of the Royal Geographical Society for July, 1888, these rocks are spoken of as "reef rock" and as "a sort of reef formation laid bare at low water and closely resembling the Recife† of Pernambuco. At certain points a very similar

* See The Geology of Fernando de Noronha by J. C. Branner, in this Journal for Feb., 1889, pp. 145–161, and Petrography of Fernando de Noronha by G. H. Williams, ibid, March. 1889, pp. 178–189. The map accompanying the former paper should be consulted in connection with the present article.

† The word Recife as it stands means a certain part of the City of Pernambuco. The author doubtless means the "recife" or reef in front of that city.

rock is found at considerable heights above the sea." He also says that "raised beaches, therefore, seem only to exist on basalt, and in close connection with a phonolite peak."

I am unable to see that basalt or phonolite have anything to do with the matter. The gross structure of the sandstone shows that its material was originally deposited in the form of sand-dunes; its beds standing at all angles at which loose sand can stand (see figs. 1 and 2). A microscopic examination

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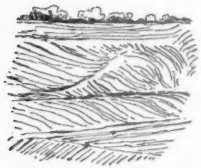
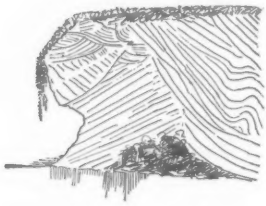


Section on Ilha Rapta.

2.

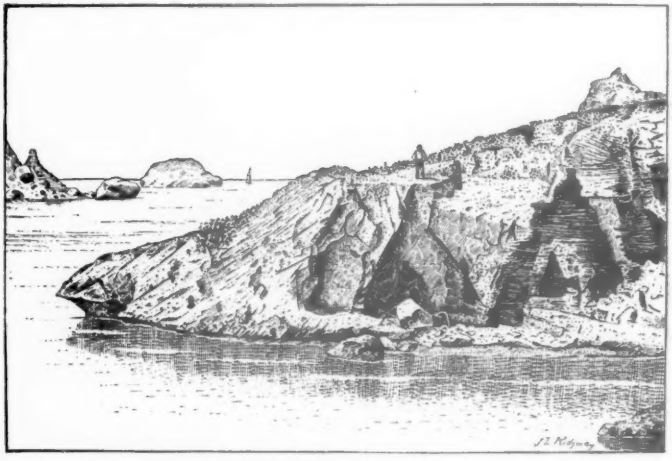


An exposure on Ilha Raza.

shows that this material has been consolidated by the interstitial deposition of carbonate of lime.

The rock varies somewhat in lithologic characters, being in some places so open and porous that it may be crumbled in the

3.



Æolian sandstone in the Bahia do Sueste.

fingers, and in others so hard and compact that when struck with the hammer it rings like "clinkstone." In places it is

made up entirely of organic matter cemented by carbonate of lime, and again it contains more or less sand and ashes derived from the igneous rocks, and thrown up by the sea along with the calcareous matter. Where the calcareous matter is most abundant and the rock is soft and easily quarried it is burnt for lime, while in other places it contains too many impurities to admit of it being used for such purposes. The principal locality from which rock is taken for the manufacture of lime is on the south side of the Bahia do Sueste (fig. 3). The deposit has been extensively undermined by the water and its abrupt faces display well its dune structure. The bedding shows that the material must have been blown to its present position from a southern or southeastern direction. Where this æolian sandstone comes in contact with the igneous rocks at this place its stratification planes stand at a high angle, showing that they were formed by the sand having been blown over the top of a dune. This wind-bedded material continues beneath the water line at this locality, and rises to a height of forty feet or more above it. The pieces of rock used for lime are taken out in flakes half an inch and more in thickness and carried to the lime-kiln. The burning requires from three to four days. The lime is somewhat impure from the admixture of small fragments of igneous rocks.

The following is an analysis* of a sample of the more porous parts of this rock burned for lime.

Analysis of specimen dried at 110°–115° Centigrade gave:

Silica	2·20 per cent.
Alumina	0·79 "
Ferric oxide	0·87 "
Lime	0·27 "
Magnesia	0·89 "
Calcium phosphate	0·67 "
Calcium carbonate	97·27 "
Magnesium carbonate	0·49 "
Potash	0·15 "
Soda	0·22 "
Total	101·72 per cent.
Water at 110°–115° C.	0·25 "
Soluble in concentrated nitric acid	96·67 "

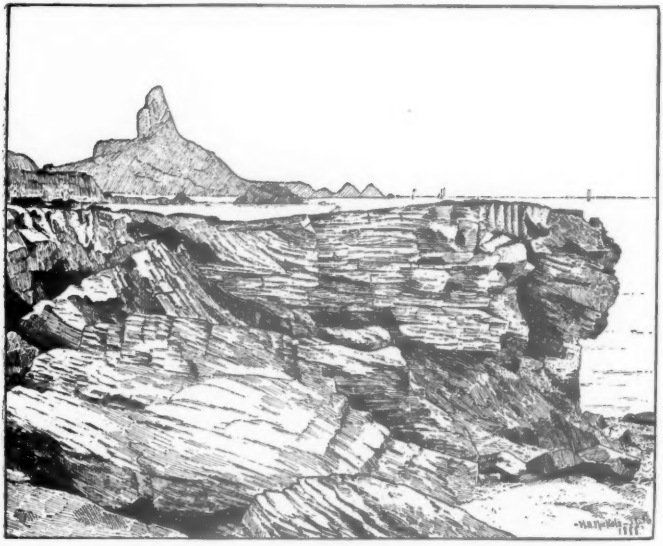
Examined under the microscope this rock is found to be made up entirely of triturated organic remains such as bits of shells, spines and shells of sea-urchins, corals, nullipores, foraminifera, and the other calcareous growths such as cover the

* Analyses by R. N. Bracket.

rocks in many places about the island, all of which is cemented by carbonate of lime. For the most part it is very porous, and the cavities are seen to be gradually filling up by the building into them of crystals of carbonate of lime. No quartz has been found in any of the specimens examined microscopically.

On Ilha Raza the bedding of this rock is beautifully exposed in a perpendicular bluff 40 feet or more in height, at whose base lie the enormous fragments that have fallen by their own weight after having been undermined by the ocean (see fig. 4).

4.



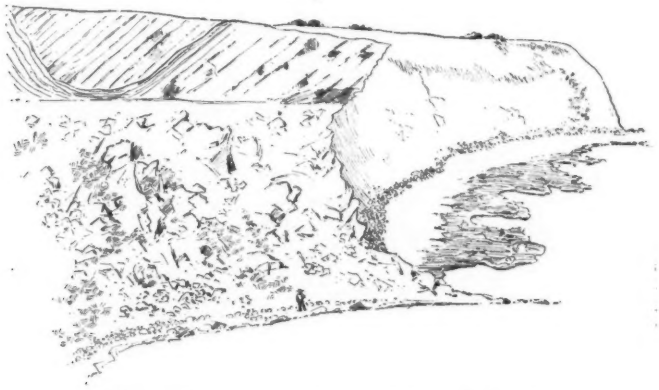
Cliff and fallen blocks of sandstone, Ilha Raza.

The wind-made bedding of the material is well shown in many parts of this exposure.

On the southeastern corner of Ilha Rapta sandstone caps the igneous rock, and rises to a height of 50 feet or more above the water (see fig. 5). Here is situated the great "blow-hole," shown in fig. 8 and described at the end of this paper, where the waves of the ocean operating through hidden passages in the rocks near the mean tide line forces a powerful jet of spray through a narrow opening to a height of more than a hundred feet, and the prevailing winds carry it east and north over the island. The water from this spray has attacked the sandstone, leaving it with a deeply etched surface, the more resisting points, from one to three feet high, being so jagged

and so close together that it is almost impossible for one to walk over them (see fig. 8). On the southeastern side of Ilha Raza the same etching of these calcareous sandstones has been caused by the surf blowing over the island (see fig. 6).

5



Æolian sandstone capping eruptive rocks on Ilha Rapta.

The southern side of Ilha Raza has been deeply undercut by the water. The rock here is more compact than at most of its exposures. Great caverns are at first worn along the line at which the force of the surf is greatest at high tide. These excavations are carried forward upon a flat floor which extends all along the southern side of Ilha Raza (fig. 6). When the undermining has reached a certain point the roof or edge of the islands breaks and falls upon this floor whence it is soon removed by the surf. It is to be remarked that all the debris coming from the destruction of the sandstone at this place is carried away by the undertow leaving the stone floor clean, as shown in the accompany illustration. I am inclined to think, however, that the removal of these rocks is due to a considerable extent to chemical action. That the salt water does dissolve the rock is clearly shown by the etching produced by the spray wherever it is blown over these sandstones. Undermining by the ocean is seen wherever these æolian sandstones occur—on Ilha Rapta, Ilha do Meio and Ilha Raza, on the Chapeo and elsewhere, but the stone floor left by the removal of the rock is most extensive on Ilha Raza.

A shelf similar to that above described usually answers the purpose of a landing place on Ilha Rapta. There is no beach on that island, and a boat or jangada can be brought beneath one of these projections at low water, enabling one to disembark by climbing up on the ledge.

It has already been noted that the wind-bedding of these sandstones upon Ilha do Meio is continued beneath the water at low tide, and that the island is now lower than it has been at some time in the past* (see fig. 2). It may be of some corroborative interest, at least, to state that the writer had reached

6.

Caverns cut by the surf on Ilha Raza.

a similar conclusion before having seen this opinion of Mr. Buchanan. Other facts, however, show that the island has experienced other changes of elevation than this single depression. That the rocks forming Ilha do Meio, Ilha Rapta, Ilha Raza, and the solitary block between the main island and São José known as "O Chapeo" are wind-bedded there can be no question. In the cases of the sandstone east of and lying against the base of Atalaia Grande, and that on the south side of the Bahia do Sueste, the wind-bedding is even more clearly shown. In the rocks of Ilha do Meio, Ilha Rapta, Ilha Raza, and in the Bahia do Sueste, this peculiar bedding is continued beneath the water line, showing, as Mr. Buchanan suggests, that the island has once stood at a higher elevation.

* The Voyage of the Challenger, by Sir Wyville Thomson, N. Y., 1878, vol. ii, p. 100 *et seq.* The opinion is credited to Mr. Buchanan, and the island is spoken of as Booby Island.

It should also be noted, however, that some of these sandstone beds, rest immediately upon beach-worn pebbles and cobble-stones. In the case of the great block of sandstone, about 25 feet high, which is the remnant of an island near São José, known as the Chapeo, the underlying conglomerate is extremely hard and is well exposed at low tide. On the southeast side of Ilha Rapta and on Ilha Raza they can be seen, though not so well exposed as at the Chapeo. Inasmuch as the cobbles must have been worn before they were covered by sand, the island must have stood at a level somewhat lower than its present one while the cobbles were being made, and as the wind bedding could not be produced below the surface of the water or in sand to which the waves had access, the island must have been elevated somewhat before the dunes were blown over and deposited upon the cobble-covered beaches.

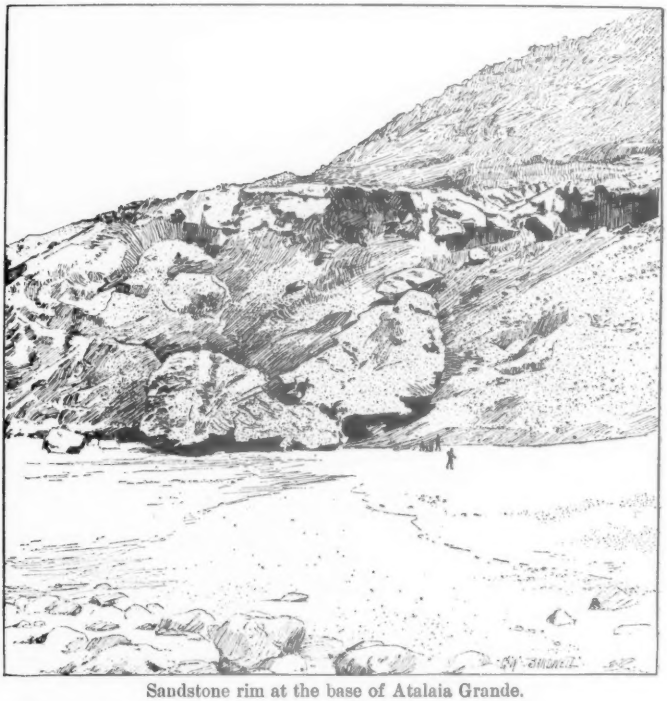
It is worthy of note that all these æolian sandstones lie upon the eastern or southeastern sides of the island, that they occur at a pretty high elevation, (70 feet on Ilha do Meiò, 90 feet on São José and about 100 on Ilha Rapta and at the base of Atalaia Grande) and that they are entirely disconnected with any of the small existing sand beaches. The former beaches must have been much more extensive than any now about these islands, for there is nowhere upon these shores a beach comparable in extent, size or thickness with the exposed beds of these calcareous sandstones, and the sea-bottom is everywhere rough and more or less rocky, a fact which precludes the idea of these beds having once existed as sediments or as immediate beaches. I have already expressed the conviction,* that these sands were blown up from the south or southeast, a conviction sustained both "by the geographic positions of the various beds, by the absence of such rocks at corresponding elevations on the opposite sides of the islands, and by the internal structure of the rocks themselves, the steeper face being toward the north or the northwest. But as there is now no beach from which this sand could have been derived,† we must conclude that the island was, not long ago, wider to the southeast, and that there were upon that side of it sandy shores, upon which a great abundance of organic remains was thrown and ground to sand. These sands were then blown across the island to and upon the opposite shore, burying the former bowlder-covered beach near São José beneath 75 to 100 feet of sand, and piling it up considerably higher than the highest parts of the existing sand-rock." They joined into one what are now the separate islands of São José,

* Ibid., p. 161.

† There are some beautiful miniature bays about the coast, but there are but few smooth beaches and these are very small.

Ilha Raza, Sella à Gineta, Ilha do Meio, Ilha Rapta, and the northeast point of the main island, while rain, charged with carbonic acid, falling upon it, and the spray blown over it from the surf, dissolved out the carbonate of lime, carried it downward and re-deposited it, thus solidifying the sand into a hard rock, upon which the ocean has gradually encroached from both sides.

7.



Sandstone rim at the base of Atalaia Grande.

The southeastern side of the island is being cut away much more rapidly than the northwestern side. This is due to the prevalence of east winds, and the northeast-southwest position of the longer axis of the group.* On the south side the spray attacks the rocks over the surface, while the more violent surf undermines them. The action of both these forces may be seen in fig. 6.

At the base of Atalaia Grande on its eastern side, the æolian sandstones form a narrow rim or shoulder, about one hundred

* During the months of July and August, 1876, the wind was almost constantly from the east, varying occasionally to a few points south of east or north of east.

feet above mean tide. The encroachment of the sea has removed the supporting igneous rocks, and great fragments, some of them over fifty feet across and twenty feet in thickness, have slid down to the beach. This ledge and its fallen fragments are shown in fig. 7. Where these rocks abut against the hill, they have a steep dip toward the island, suggesting that the bedding was produced by sand having been blown over the top of a dune.

Of the ancient sands but few unconsolidated remnants are now to be found upon these islands. On the top of the ridge at the extreme northeast point of the island is some not hardened into solid rock. This sand like that of all the present beaches about the island has a clearly marked sonorous property, crunching and creaking beneath the feet like dry snow.

In 1881 the Brazilian Minister of Agriculture sent a commission to Fernando de Noronha to examine and report upon the phosphate of lime found on Ilha Rapta. This phosphate of lime overlies the æolian sandstone of that island, and Mr. Derby says in his report* that it is probably the insoluble residue from a deposit of guano, the parts soluble in water having been washed out by rains. Mr. Derby's explanation is no doubt the correct one. It may be added, however, that this phosphate occurs over the etched surface of the calcareous rock, and this rock has doubtless added to the total amount of phosphate of lime on the island for this amount would be materially increased by the presence of the calcareous rock underlying the deposit. The rainwater would dissolve from the guano the soluble phosphates of lime and ammonia and these, upon coming in contact with the carbonate of lime beneath, would form insoluble phosphate of lime and soluble carbonate of ammonia, the latter being carried off.

The writer observed several illustrations of the formation of solid rock-like masses of the insoluble phosphate of lime in what seem to have been crevices or porous vertical streaks in the calcareous rock. Of the following analyses, No. 1 is of this hard phosphatic rock broken from the indurated æolian sandstone.

It is noteworthy that typical specimens of these æolian sandstones, whether very porous or compact, and whether from Ilha Rapta or elsewhere, show upon analyses the presence of some phosphate of lime. Analysis 2, beyond, is of the average clean and compact part of the Ilha Rapta æolian sandstone. The piece was broken from one of the tall jagged points left by the etching out of the surface by the combined action of rain water and ocean spray.

*My copy of this report has for title simply "O Phosphato de Cal;" it bears neither place nor date of publication, but it was probably published by the Brazilian government in 1881 at Rio de Janeiro.

1. Specimen dried at 110°–115° C.:

Silica	1·77 per cent.
Alumina	8·81 "
Ferric oxide	6·35 "
Lime	0·15 "
Magnesia	0·13 "
Calcium phosphate	18·35 "
Calcium carbonate	41·62 "
Magnesium carbonate	22·17 "
Potash	0·12 "
Soda	0·48 "
Loss on ignition	1·81 "
Total	101·76 per cent.
Water at 110°–115° C.	1·44 "
Soluble in concentrated nitric acid	95.94 "
Insoluble in " " "	4·06 "
Total	100·00 per cent.

2. From the surface of the æolian sandstone from Ilha Rapta. Specimen dried at 110°–115° C.:

Silica and matter insoluble in concentrated nitric acid	0·09 per cent.
Alumina	0·45 "
Ferric oxide	0·13 "
Calcium phosphate	0·82 "
Calcium carbonate	98·33 "
Magnesia	0·64 "
Potash	0·10 "
Soda	0·20 "
Total	100·76 per cent.
Water at 110°–115° C.	0·17 "
Soluble in concentrated nitric acid	99·91 "
Insoluble in " " "	0·09 "
Total	100·00 per cent.

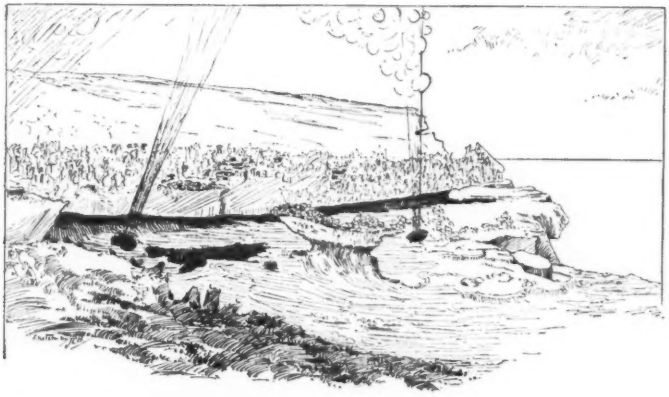
It should be noticed also that the analysis of the very porous rock from the Bahia do Sueste used for making lime shows the presence of phosphate of lime.

In his report upon the phosphate beds of Ilha Rapta Mr. Derby refers to a piece of a Millepora having been found in the higher parts of the calcareous sandstone beds of that island and from this he seems to infer that they were deposited under water. Of the many pieces of organic remains I have found in this rock I have never seen one whose presence so high above water might not readily be explained by supposing it to have been blown up a gently sloping beach by the wind. The place referred to by Mr. Derby is, however, a peculiar one in

this respect, and not only animal remains but stones the size of a man's fist may be found where, under ordinary circumstances, it would be quite impossible for the wind to blow them.

On the south side of Ilha Rapta where the æolian sandstone comes in contact with the underlying eruptive rocks, at a place known as the *Funil* or "blow-hole" already referred to, a maze of subterranean channels has been cut out by natural processes. The upper part of the sandstone is worn away leaving a thin but compact horizontal crust forming the roof

8.



of these caverns (see fig. 8). Through this roof are three or four openings, and at certain stages of the tide the waves beating against the shore, at this point V-shaped in outline, crush and compress into these subterranean channels great bodies of air which, when they happen to be carried to the openings through the roof, escape with enormous violence. I have seen the spray from one of these holes (the one seen on the left in the sketch), thrown to a height of more than a hundred feet. Sometimes but little water is ejected, the air escaping with a loud explosion and resembling hot air rushing under pressure from a furnace. These explosions come principally from the vent shown on the right in the illustration. At other times a great body of water spurts from the largest of the openings—the one in the middle of the foreground. One of the prisoners living on Ilha Rapta told me that he had known fishes and stones to be thrown out by these jets of water and to fall on the sandstone above. There are a few loose stones lying over the surface of the calcareous rock within the range of the falling spray, and it is not improbable that fragments of corals, impossible of transportation by the wind, might be in this way thrown upon the higher parts of the calcareous sandstone.

Art. XXXII.—*A Mountain Study of the Spectrum of Aqueous Vapor;* by Charles S. Cook.

A complete study of the Solar Spectrum necessarily includes, not only a determination of the position of all lines, but also an estimation of their relative intensities. While the means of determining the position of lines leaves little to be desired, it is a remarkable fact that no satisfactory method of measuring the intensity of the absorption lines has been devised. The instrument devised by the writer for the study of the variations of some of the terrestrial lines has done excellent service, and it is possible that it might be adapted to more general use in the study of the spectrum. While observations have been made on a number of the atmospheric lines due to dry air, the study of the aqueous vapor lines has proven most interesting. Two spectroscopes of identical construction were made especially for this work. They were provided by the United States Signal Service.

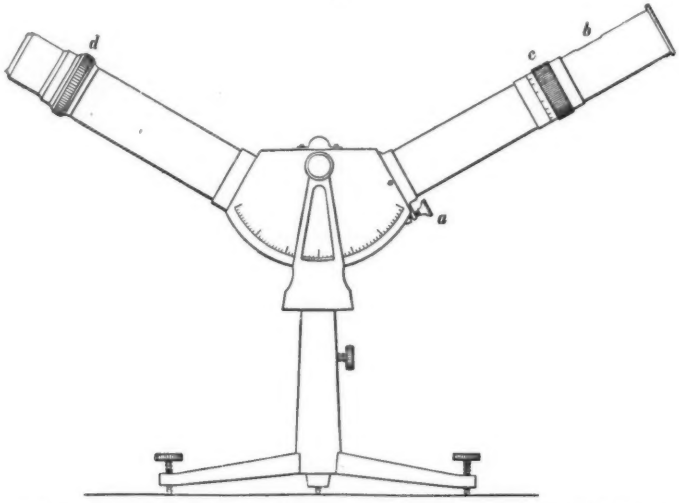
The first requisite in such an instrument is that it shall give a bright spectrum. As observations must be made on dark, stormy days, every effort must be made to secure a strong illumination. This is attained by the use of a large collimating lens and prism, and a large angular aperture for the collimator, which makes it best that the collimating tube be short. Only moderate magnifying power in the observing telescope is desired, as a high power would make the spectrum appear faint.

Another requirement of a general nature is that such a spectroscope shall be so designed that it is not liable to be accidentally thrown out of adjustment; for a slight change in the focus or in the width of the slit, while it might not be detected, would make a great error in the photometric value of the spectrum lines. For this reason, each draw-tube should be provided with a set screw, and the slit adjustment should be controlled by parts which are inclosed within the cap at the end of the collimator. Reference is not made here to a brass cover which must be removed when the instrument is used, but rather to a cap with a plane glass front which is never to be removed during the course of a series of observations. This last requirement, unfortunately, is not met in the spectroscope as constructed for use, as the maker violated his instructions in that particular, as he did not find it convenient to inclose the adjusting collar *d* in the cap. Fig. 1.

The instrument has an altazimuth movement, and is provided with leveling screws and a spirit level, which last is fastened to the top of the prism case. A graduated arc shows

the angle which the tube makes with the horizon. At "*a*" is the screw by which the telescope is turned to view different parts of the spectrum. The attachment which permits of a photometric measurement of absorption lines appears at "*c*."

1.



The object sought is the production of an artificial line whose intensity can be varied at will. This fictitious line is placed alongside the spectral line which is to be measured, and the intensity of the former is then varied until the two appear like. As this variation in the blackness of the artificial line is effected by the use of a micrometer screw, its readings constitute an arbitrary value of intensities. The artificial lines (there are a pair of them) are diffraction fringes. They are produced by a single silk fiber placed slightly beyond the focus of the eye-piece. As seen in a telescope or microscope, such fringes are quite indistinct; but in the spectroscope, the fiber is in light which is practically monochromatic, which greatly favors distinctness of definition. Much improvement is effected also by viewing the spectrum through a narrow opening parallel to the fiber and consequently parallel also to the spectral lines. A piece of blackened brass is placed on the eye lens next the eye. In this cover is cut a slit one millimeter wide, extending entirely across the lens. It is found that the definition of the artificial line is improved if this observing slit is eccentric. The edge of the slit should be placed at the center of the eye lens, making the slit one-half a millimeter displaced upward or downward.

The variation in the comparison lines is effected by turning the micrometer screw or collar "*c*." The rotation of this collar causes a diaphragm bearing the silk fiber to slide within the observing tube and so remove the cross line from the focus as far as desired. As the fiber is withdrawn from the focus, the single sharp image of the line is replaced by a pair of sharp lines exceedingly close together. On further motion, these diffraction lines slowly separate, becoming fainter until they finally become invisible. Whole revolutions of the micrometer screw are read at "*b*," where a portion of the sliding diaphragm is exposed. The screw itself is divided into tenths, and these tenths constitute the arbitrary units of intensity used. The whole range of the instrument is about four revolutions of the screw, or a range of forty of these units. The probable error of the mean of a series of readings such as was usually taken is found to be somewhat less than one of these units.

No good work can be done with such instruments without carefully shielding both eyes from extraneous light. The observations were nearly all made on a single line of the aqueous vapor spectrum, the strongest of them all, the line in the red near the "D" line.

Observations were made regularly at altitudes of 5 degrees, 10 degrees, 20 degrees, 30 degrees, and 90 degrees, for a time at the horizon also.

In the mountain work, the two duplicate instruments were used in simultaneous observations. Although they were of identical construction a comparison was made, the assistant and myself making readings side by side and comparing results. A difference of a very few units was observed, clearly due to a difference of eye-sight.

The observations described in this paper form a part of a series continued with a few interruptions during several years, most of them being made at the Shattuck Observatory of Dartmouth College, Hanover, New Hampshire.

Three trips have been made to the White Mountains, with the idea of studying the behavior of the spectrum of aqueous vapor. The first trip resulted in little or nothing of value, the unfavorable nature of the weather, among other reasons, defeating the purpose in view. A second and more successful trial was made in the summer of 1886, and again in 1887, a stay of two weeks being made each summer. The most important object sought was to gain some evidence as to the height to which aqueous vapor extends during stormy weather; or, more comprehensively, in how far the spectroscope is competent to give information as to the height of vapor in all kinds of weather. Other questions were also considered, and more or less information bearing on them was gained.

The mountain selected was Moosilaukee Mountain, one of the outlying peaks of the White Mountain range. The altitude above sea level is 4,811 feet. Observations were made at the summit at frequent intervals, while an assistant, Mr. E. B. Frost, made simultaneous observations at a station well down toward the base. The horizontal distance between the stations was about three miles. The difference of altitude was very closely 3,000 feet. In addition to the spectroscope readings, the ordinary meteorological observations were taken.

On studying the varying appearance of the aqueous vapor lines in the solar spectrum, one is impressed by the very wide range of variation in their intensity. One day the strongest of these lines may be almost invisible, while a few days later it is no exaggeration to say that its intensity is forty times as great, perhaps I might safely say sixty or more times greater. Assuming as we may that for a single line the light absorptive power of the vapor is proportional to the amount of vapor traversed, we are led to infer that on the second day there was at least forty times as much vapor present as on the first day. Does this mean that the absolute humidity was forty times as much? The hygrometer shows nothing approaching such a range. During the summer weather rarely does the amount of water in a cubic foot of air on a *wet* day exceed by more than five times that present on a *dry* day. Instead of assuming that the air holds forty times as much per unit of volume, is it not nearer the truth to assume rather that the vapor extends upward forty times as far in the atmosphere? I say nearer the truth, with certainly no desire to deny the effect due to other causes. But I do wish to emphasize, and strongly, that the prevailing disposition to associate the varying vapor spectrum with varying humidity, with tacit understanding that other factors are acting, is all wrong. We should associate the varying spectrum with varying vapor altitudes, remembering always that other factors play a subordinate part. It is true that a chart on which are platted together vapor line intensity and absolute humidity does show a very fair, indeed I should say a close accordance; but this is due in the main not directly to an interdependence, but rather indirectly to the fact that damp air and high vapor altitude generally go together.

At the time the observations were made on the mountain, the importance of the question of vapor altitude was not appreciated. It was thought, as indeed is true, that the difference between the spectra observed at the two stations with identical instruments would represent the absorption of the stratum of the vapor between the stations, i. e., a depth of 3,000 feet. It was carelessly presumed that in consequence the spectrum difference would be greatest whenever this 3,000

feet of air contained the most water—when its humidity was greatest. After returning home, the figures obtained were tabulated, and the results platted in curves. To my surprise no such relation appeared. Indeed, there was rather more than a suggestion of the contrary—the paradoxical appearance that the more vapor present in the 3,000 feet of air, the less the light absorptive effect produced by it. The effect of altitude of vapor was then more closely considered, and it was at once apparent that if there were great variation of altitude its effect might be as observed. Let us illustrate this point by the facts observed. On many days, so little vapor was there above the level of the summit of the mountain that the aqueous vapor spectrum contained no line of measurable strength; indeed, it was sometimes invisible. At the same time at the lower station the line was very easily measured. Indeed, once only did the line utterly fail to appear at the lower station. This was after a long storm, and about twenty-four hours after the rain ceased, and about twelve hours after the clouds broke away.

On another occasion, the day following the close of a heavy storm, about thirty hours after the rain ceased, and about seven hours after the clouds broke away, a very faint spectrum was observed at the summit. Here it could be directly seen that there was much vapor at a low level, with exceedingly little at a high level. The spectroscope acted just like a telescope. When pointed at the horizon, a very distinct line was seen measuring 25 units. When elevated 5 degrees, a very faint line of only 6 units was seen. A most striking and unusual difference for this small difference of altitude. The lower stratum of air in direct contact with the earth was well charged with moisture by evaporation from the wet earth, while the upper air was completely exhausted of moisture by the storm which had passed. The air was exceptionally clear at this time—as clear as I have ever seen it.

During several equally clear days in September, when the weather was cool, and the air very dry, the line at the horizon ranged between 0 and 10 units. It was only in fair weather and long in advance of rain that the spectroscope revealed no vapor above the mountain top.

Returning now to the point under consideration, we have noted a condition of the atmosphere when there is no vapor line to be seen at the top, with a moderately strong line of say 25 units at the base. The spectroscope difference is then 25—0 or the whole 25 units. The maximum difference between the two stations is then obtained when the vapor line is 0 at the summit. This difference will be a minimum when there is a very great amount of vapor above the summit. It is easily seen that if the vapor extends to a height of several miles in

all, the vapor contained in the stratum of 3,000 feet which we are studying becomes a small factor in the whole. The observer at the top of the mountain we suppose has several miles of damp air to look up through. The observer at the base has this same distance of several miles plus 3,000 feet. The spectra will not be proportionally very different. We repeat then that the minimum difference between the spectroscopic observations at the top and bottom of the mountain will be observed when the vapor extends to the greatest height in the atmosphere. This will naturally be during the progress of a storm. It is found that such is the case.

In looking over the records, I find the difference very generally small in threatening weather, becoming sensibly 0 in case of actual storm with precipitation.

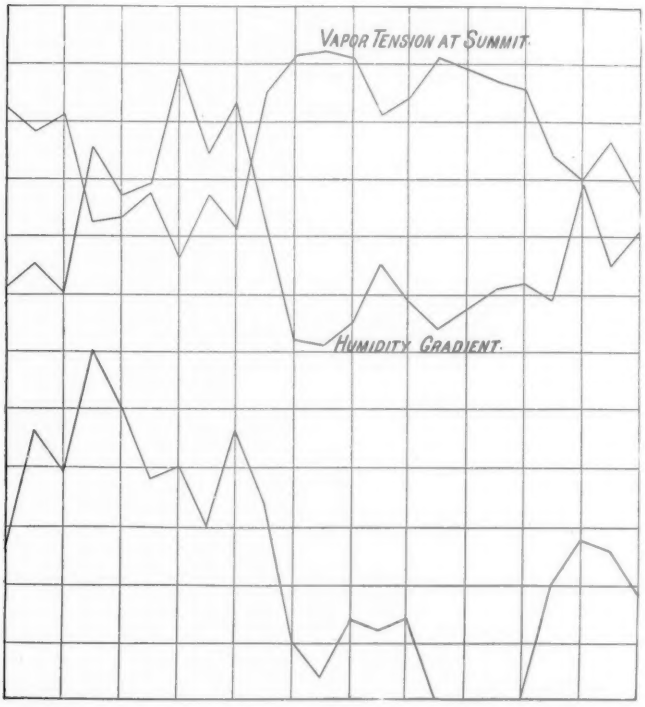
In only one case is the reading at the upper station greater than a simultaneous one lower, 8 units in this case. This represents an impossibility, and means simply an error in the reading on the part of one of the observers. A difference of 1 to 3 units is not considered significant, in view of the very considerable difficulty of such work. When we consider that the two observations were, from the circumstances of the case, made absolutely independently, with constant and large fluctuations in the readings, and that the observation is one of great delicacy, we must consider this result a very gratifying one.

Let us see what light is gained from averaging the observations as far as possible. (We are obliged to exclude many observations mainly on account of the interference of clouds.) We have seen that the difference is a maximum when the line is 0 at the top, i. e., when the absolute humidity is least. I assume a vapor tension of 0·4 inch as the average humidity at that altitude, and find the mean of all spectroscopic differences when the vapor tension was less than this; and also in the same way when the tension is greater than this. With a tension of more than ·4, the mean difference (17 readings) is 8·5 units. With a tension of less than ·4, the mean (14 readings) is 15·7 units—a ratio approaching two to one, and amply sufficient to establish the point. The same thing is illustrated by a diagram. Fig. 2. It compares the same two quantities, having a curve for spectral difference,* and one for the summit humidity. The two should correspond. A third curve is added which should be antithetical. This curve represents the difference of vapor tension at the base and summit; in other words the humidity gradient. If the humidity falls off but little in ascending the mountain it seems probable that one would have to go to a great height in the atmosphere to reach a point of low

* This is the lowest of the curves on fig. 2.

humidity. On the other hand it is assumed that if the humidity falls off rapidly vertically there will be little moisture in the upper atmosphere. If the spectroscope is a competent witness, we must believe that at times no significant amount of vapor exists above the level of a mountain top

2.



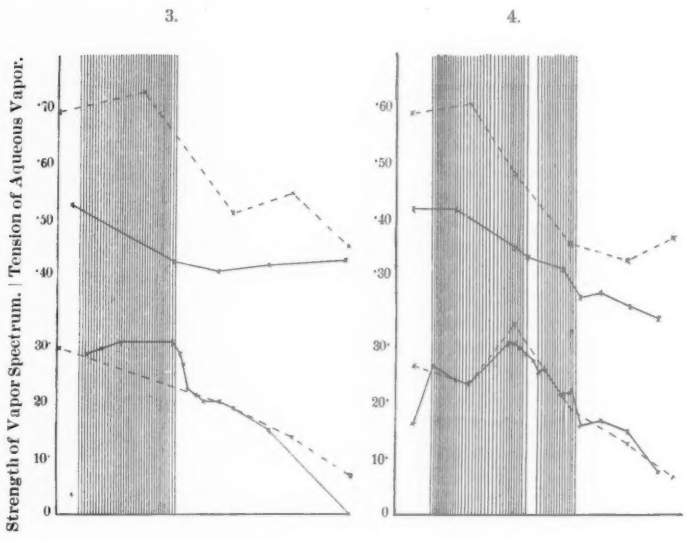
whose sea level altitude is over 0·9 mile, which height for convenience of discussion we will call a mile. This no doubt no one would call in question. The spectroscope would also lead us to believe that at times there exists at a height greater than one mile such a quantity of vapor that an additional 0·6 of a mile of very damp air is not a significant addition. It is true that in stormy weather observation is difficult, so that the closest work cannot be done; it is very hard to say how great a proportional part could be easily recognized. Some rough idea of this may perhaps be gained from the diagram displayed.

A question of much interest is the effect of the passage of light through clouds. It is certain that the optical effect of

storm clouds is at times something very great, I may say enormous. This has long seemed to call for some explanation. I regret to say that I am far from being able as yet to establish any theory, and can only submit certain evidence bearing on the question. I conceive that there are three causes which may act separately or conjointly to produce the great absorption of light by storm clouds. We may conceive (1) that a storm corresponds to a great altitude of aqueous vapor, and a consequent great length of air column traversed by the rays of light. (2) That a cloud allows light to pass by a process of multiple reflection: the particles of mist being so close together, it is conceivable that the broken lines representing the actual path of any one ray of light would when rectified have a length of several times the actual thickness of the cloud. (3.) That water when passing from the form of vapor to that of a liquid, i. e., while in the act of condensation, has an abnormally great effect. This view has had its advocates, but I know of no physical evidence of such action, and am rather disposed to believe that the idea was put forward merely as a possible explanation of this cloud action, with no other evidence in its favor. A direct test of this third theory of the abnormal effect of saturated air or perhaps more accurately of nascent cloud, has been made repeatedly by the writer. Doubtless, many present have watched from a high mountain the formation of cumulus clouds on a sunny morning, and have noticed that the lower surface is an almost perfect plane. The upper surface may be ever so much broken and piled up in rounded masses and columns, but the lower surface is ever plane. As the air rises steadily, the upper part of the cloud is seen to ascend while the lower part is stationary, the cloud particles here being renewed as fast as they rise. At the lower surface, then, we have continuously nascent cloud, and light traversing this stratum should show abnormal absorption if it exists. The result of observation is negative as far as recognizing such an effect is concerned. It must be said, however, that the illumination is poor necessarily, and for this reason it cannot be claimed that the theory is disproven.

Now while more than one of the above causes of absorption may well be concerned, it seems that any very marked predominance of one of them can be discovered if it exists. For this reason, I was interested to determine if when both stations were immersed in a storm cloud the 3,000 feet of cloud between would give much difference of line. But storm clouds will not come at one's bidding; and when they do come they are very likely to come at night, consequently the amount of evidence is not very satisfactory. Only twice were the conditions favorable, that is, on only two days could the tests be

made. The readings taken showed no difference within the limits of reading of the instruments. How closely the two readings agreed is shown in the diagram. Figs. 3 and 4. The shading indicates rain-fall, the heavier shading corresponding to rapid precipitation. The full lines represent observations at



the summit, the broken lines those at the base of the mountain. Unfortunately in the first instance as shown in figure 2, very few observations were taken at the base so that the comparison is not satisfactory.

An observation made on the mountain top August 6, 1887, gives quite direct evidence on the relative efficacy of damp air and storm cloud in producing a spectrum. As the chart shows, it had rained steadily during the previous night and from 9 to 12 of the forenoon, and during two hours of this my assistant's record says that it "rained furiously." At 12.15 the rain ceased falling. As usual the intensity of the vapor line fell off rapidly (see fig. 4). Fifteen minutes after the rainfall ceased, the clouds in which the mountain had been immersed broke away for a few minutes. We saw far above us bright cirro-cumulus clouds, thin and much broken, showing considerable blue sky through the breaks. The zenith reading with the spectroscope was 22, an exceedingly large reading for a zenith reading on a nearly cloudless sky. I believe it is the highest reading ever obtained on such a sky.

It can only be explained as due to the very high vapor concerned in the storm just ceasing. It is of course very unusual for the air to clear so soon after rain ceases. It is to be noted that the vapor line was not so very much less intense on the sky and thin cloud than it was on the storm cloud an hour before when it was "raining furiously." Some three hours later, i. e., at 3.15, the cloud had settled down again so thick that spectroscopic readings became difficult, yet the line had diminished to an intensity of 15. Whatever weight we may assign to those observations must be thrown in favor of the first cause mentioned, viz: that the great optical effect of storm clouds is due to their being associated with a very high altitude of vapor. As 3,000 feet of cloud seemed to exert no great optical effect, the second cause suggested (multiple internal reflection) does not appear as the predominating source of action. The result is no more favorable to the theory of abnormal action of saturated air. Much more conclusive evidence could be secured if one of the observers were above a storm cloud. A brisk shower would answer the purpose quite well. With such conditions, the effect due to the cloud would be isolated, and it would appear that the question would be solved. Unfortunately, no such conditions presented themselves to us.

It is rather remarkable that no amount of fog appears sufficient to produce any spectroscope effect. At Hanover, where most of the observations have been made, dense fogs are very common, especially during the fall. Innumerable observations have failed to detect more than a trace of action. Often in the morning the darkness would be so great that one would be very uncertain as to the weather, the presence of clouds as well as fog appearing probable. The sky might be so dark as to make readings difficult, sometimes they were as difficult to make as in the presence of a storm. Under such circumstances, the spectroscope infallibly discriminated, rarely showing any line at all in case of mere fog, while in the presence of storm cloud it would be strong. The mere matter of brightness or darkness of a stratum of cloud gives no clue as to the strength of the line to be observed. Considerable attention has been given to this point. As an example, I will give the result of a comparison made Aug. 25 and 26, 1886, the observations being on the summit of Moosilauke Mt. The 25th was stormy, rain beginning to fall at noon, falling steadily till 2, and intermittently afterwards. About 0·2 of an inch fell in all. Observations taken on the cloud or rather in the cloud as the mountain was enveloped constantly, during the lulls, i. e., when it was not raining, gave readings of 16, 21, 24, 23, 25 and 20. On the next day no rain fell but otherwise the conditions of things

appeared to be the same, but the aqueous vapor spectrum was very faint. To quote from the record made at the time: "At noon with clouds of the same darkness, and with the circumstances all apparently the same as on yesterday, the line is very faint. Hence the clouds at noon, at the time of their greatest illumination, gave readings of as great difficulty as yesterday, and yet they are all persistently 0." On the preceding day, they had averaged 21. At four in the afternoon the cloud grew evidently thin, and at six the sun could be easily distinguished. This is but one of many instances that might be quoted. An excellent example of the discriminating power of the instrument in this direction is worth giving here. During daylight of Aug. 5, 1886, a storm rapidly gathered. During the night rain fell steadily. During the forenoon of the next day, Aug. 6, it rained very heavily. We were closely wrapped in cloud all day, the vapor line being 15 to 30. The third morning we found ourselves in cloud as usual. The spectroscope gave a vapor line of 0. At the breakfast table, at about nine, one of the guests (a professor of Civil Engineering, who ought to be a good practical weather prophet if anyone, surely) remarked it was a most discouraging outlook. I was very happy to assure him that "the cloud was only a cap, or at most part of a thin sheet of cumulus cloud which could not possibly give us any more rain; that the storm was all past, and nothing but fair weather clouds remained." In about two hours the clouds lifted, revealing the clearest of atmospheres, and showing us that the cloud layer was very thin broken cumulus. It was an exceptionally fine day.

To sum up the points considered:

1. The spectroscope is competent to give trustworthy evidence as to the amount and distribution of aqueous vapor in the atmosphere.

2. The spectroscope studies vapor height primarily, and humidity only secondarily.

3. During stormy weather vapor ascends to altitudes greater than is usually supposed.

4. The great absorption of storm clouds is due to their great thickness, or to extensive strata of damp air associated with them, more than to any peculiar behavior as clouds.

ART. XXXIII.—*On the occurrence of Basalt Dikes in the Upper Paleozoic series in Central Appalachian Virginia;* by NELSON H. DARTON, U. S. Geological Survey. *With notes on the Petrography;* by J. S. DILLER, U. S. Geological Survey.

DURING a recent detailed examination of the geology of the Appalachian region west of Staunton, Virginia, the writer discovered a number of small basalt dikes traversing the Upper Silurian and Lower Devonian beds in Highland county, Virginia, and Pendleton county, West Virginia.

The most conspicuous outcrops are about a mile SSW. of Monterey, in a remarkable conical hill rising abruptly 60 to 70 feet above the valley of Lower Devonian black slates. Owing to the deep disintegration and debris of the basalt, the outcrops on the hill slopes are few, short and unsatisfactory, so that only the more general relations could be determined. The dike extends through the center of the hill and is a nearly vertical, irregularly lenticular mass varying from fifteen to twenty-five feet in thickness and bearing numerous small branches. It does not appear to have materially altered the enclosing shales, or disturbed their gentle dip except in the immediate vicinity of the dike. On the eastern side of the hill the contact is characterized by the presence of large masses of breccia, consisting of shale and sandstone fragments imbedded in basalt. The trend of the dike is SW. and NE., while the strike of Appalachian folds in this region is SSW. and NNE. At this locality the basalt was not found to extend beyond the area of the hill, but on the mountain slope, two miles westward, there is a dike of similar material penetrating the Silurian (Oneida-Medina) sandstone.

The next occurrence observed was on the west slope of Jack Mountain on the road to Doe Hill, Virginia, where an obscurely exposed dike penetrates the Silurian (Lower Helderberg-Niagara) limestones along a NE. and SW. line and in trend with the Monterey outcrops.

Three miles east of this exposure is another dike in a knoll two miles WSW. of Doe Hill, just north of the road to Jack Mountain. This dike forms a prominent outcrop over a small area, extending for a short distance across a Silurian-Devonian (Oriskany) sandstone and Silurian limestone belt with a width of about twenty feet. Its contact relations could not be determined.

Two other small outcrops were found, both in the southern part of Pendleton county, West Virginia. One is an obscure exposure in Lower Devonian slates, crossing the road two and

a half miles due north of Doe Hill and the other a dike in Silurian limestones the same distance due NE. of Doe Hill near the road that extends NW. from Palo Alto.

The nearest known outcrops of other intrusives are the basalt dikes near Wier's Cave, 40 miles east, and those near Brooks' Gap, 5 miles NW. of Harrisonburg, Va., to which Mr. H. R. Geiger has called my attention. The nearest trap areas in the Trias, are 70 miles east.

Petrographic notes by J. S. Diller.

Four specimens collected by Mr. Darton at the localities mentioned above have been examined microscopically. One is of the contact breccia and the other three are of the dikes. All are of the holocrystalline porphyritic type of basalt and differ but little among themselves. The one from the west slope of Jack Mt. on the road to Doe Hill is the best type. The porphyritic crystals of olivine and augite in about equal numbers vary from 1 to 5 millimeters in diameter, and are sufficiently abundant to render the rock conspicuously porphyritic. The dense dark groundmass under the microscope is seen to be composed of plagioclase, augite and magnetite.

The porphyritic crystals of augite are of orange gray color, often with deeper colored brownish borders. The crystal faces are usually rough and jagged. In the groundmass the augite is irregular granular and that of the second generation is frequently clamped between the small feldspars. The olivine appears chiefly in porphyritic grains whose outlines suggest crystalline form. Small grains in the groundmass are less common. Like the augite it includes some magnetite, and furthermore a few crystals of a brown octahedral mineral supposed to be picotite. The plagioclase is scarcely as abundant as the augite. It is of a basic variety and the lath-shaped crystals are usually smaller than $\cdot 01 \times \cdot 05$ millimeters. Magnetite in crystals and irregular grains is well represented both in the groundmass and as inclusions in other minerals, especially in the augite and olivine. An interesting feature is the occasional presence of small scales of biotite in the groundmass, in which respect it resembles the eruptives of the Triassic areas along the Atlantic slope.

The basalt from the hill a mile SSW. from Monterey differs slightly from the one already noted, being less porphyritic. No mica was discovered in its groundmass. The fragment from the dike of the knoll two miles WSW. of Doe's Hill looks in the hand specimen very like the one from the west slope of Jack Mt., but in thin section it is conspicuously different. Granular augite in the groundmass is much less distinct and opaque black grains became very abundant ren-

dering the section much less transparent. The rocks, however, are all of the same type and their differences so slight that they very probably all belong to the same system.

A specimen collected by Mr. H. R. Geiger from a dike in limestone of the valley near Brook's Gap, 5 miles northwest of Harrisonburg, Va., is closely related in composition to those collected by Mr. Darton farther to the southwestward. It is holocrystalline but not porphyritic, and characterized by the structure which Judd has designated ophitic. The magnetite and granular olivine are much less abundant than the augite and the lath-shaped plagioclase. The locality last named is nearer the Triassic than those in the region of Monterey. At a point 3 miles south of Lovettsville, Loudon Co., Va., in the Blue Ridge district and nearer the Trias than any of the other localities, Mr. Geiger discovered another dike from which he collected a hand specimen that in every way resembles the Triassic eruptives. This similarity is fully borne out by a microscopic examination which shows the rock to be composed essentially of augite and plagioclase, and to have a regular ophitic structure like the majority of those within the Mesozoic belt.

It is well known that the eruptives associated with the Trias of the Atlantic slope from Massachusetts to North Carolina extend beyond the limits of that formation in Pennsylvania and several other States, but as yet it appears that comparatively little is known of their real distribution. Their wide extent and remarkable uniformity of composition offers an interesting field for investigation.

Petrographic Laboratory, U. S. G. S.,
Washington, D. C., Dec. 31, '89.

Art. XXXIV.—*Additional Notes on the Tyrolite from Utah;* by W. F. Hillebrand and E. S. Dana.

1. *Composition of Tyrolite*, by W. F. Hillebrand.

On a former occasion* in discussing my own and Mr. Pearce's analyses of the mineral supposed to be tyrolite, I proceeded on the assumption that the SO_3 found by both of us should be excluded as probably derived from admixed gypsum. Since then I have made another analysis on material collected by myself at the Mammoth Mine, in September, 1888. So pure did the material appear to be that strong hopes were entertained of finally settling definitely the composition of the

* Notes on certain rare copper minerals from Utah, this Journal, III, xxxv, 300, 1888.

mineral. That these hopes were fallacious a comparison of the subjoined analysis with the earlier ones at once shows:

CuO	45·08
CaO	6·78
As_2O_5	28·52
H_2O	17·21
SO_3	2·23
Fe_2O_3	0·08
Insoluble	0·16
	100·06

The percentage of SO_3 is practically the same as formerly found (2·27 and 2·45 per cent). Under the microscope there appeared no foreign impurity approximating in any degree to 6·8 per cent of the whole mass, which would be the amount of gypsum represented by the SO_3 found. It therefore appears necessary to consider the latter as a proper constituent of the mineral, but the construction of a probable formula is not rendered thereby less difficult, and will not now be attempted.

A few words may properly be added in reference to the behavior of the mineral on drying over sulphuric acid and on heating. That the large amount of water given off to dry air is not altogether or probably even in large measure hygroscopic water, appears from the following table, which shows the loss sustained by 1 gram of the powdered mineral in a desiccator over sulphuric acid.

Hours exposed.	Loss.
18	·0231 gram.
26	·0083 "
23	·0029 "
24	·0012 "
23	·0008 "
24	·0001 "
25	·0003 "
24	·0002 "
24	·0003 "
48	·0006 "
24	·0002 "
283	·0380 "

Purely hygroscopic water would probably have been entirely removed from a mineral like this after a very few hours exposure. The table shows also that the element time may often play an important part in determinations of this kind. The experiment might reasonably have been considered ended after the 158th hour when a loss of but $\frac{1}{10}$ mg. was shown during 24 hours, but nevertheless a nearly steady loss of $\frac{3}{10}$ mg. per day took place for six days more, and might have been longer observed but for the interruption of the experiment. This may account for a marked discrepancy between the amount lost at 280° C. in a former experiment (l. c. p. 302)—10·34 per

cent—and that observed in the present case at the same temperature—14·33 per cent. In the latter the drying and heating at continually rising temperatures had continued during a period of 528 hours, the weighings being made usually from day to day, whereas in the former case the duration of the experiment was much shorter and the intervals between weighings were but a few hours each.

2. *Crystalline form of Tyrolite*, by E. S. Dana.

Among the specimens of tyrolite recently received from Dr. Hillebrand, there are several which are crystallized with sufficient distinctness to allow of a somewhat more complete determination of the form than has hitherto been possible. The crystals are in thin tables or scales flattened parallel to the basal plane of cleavage, and they are united by one edge so as to form radiating fan-shaped groups having a rounded and deeply striated exterior. Occasionally minute isolated crystals can be observed. These are seen under the microscope to be bounded by the pinacoidal edges parallel to which extinction takes place; further, the bisectrix is found to be sensibly normal to the tabular plane of cleavage, so that they can be referred to the orthorhombic system with little question. Besides the pinacoids, the crystals are bounded by two prisms, 110, and 120, the former having a normal angle in front of 86°, while the latter is inclined to 010 at an angle of 28°. From the first angle we calculate:

$$\breve{a} : \breve{b} = 0.9325; \quad 120 \wedge 010 = 28° \ 12'$$

No planes were observed which could fix the length of the vertical axis. The crystals are elongated parallel to the macro-axis and the optic axes lie in the brachydiagonal section, the bisectrix being normal to the base; the character of the double refraction is negative and the axial angle large.

Art. XXXV.—*The Origin of the Soda-Granite and Quartz-Keratophyre of Pigeon Point;* by W. S. Bayley.

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In this Journal for January, 1889,* the writer described a red rock from Pigeon Point, Minnesota, with the characteristics sometimes of a soda granite, sometimes of a quartz-keratophyre. The first is a fine grained, drusy rock, speckled with little spots of a dark-green color. It is composed essentially of a hypidiomorphic granular aggregate of two feldspars, quartz, chlorite

* Jan., 1889, pp. 54–63.

and a few subordinate constituents. The second variety resembles quartz-porphyry. Well terminated quartz crystals and occasional brick-red and greenish white feldspars are scattered through a very fine grained, dark red or purple groundmass, whose major portion consists of a granophyric intergrowth of quartz and red feldspar. Both rocks exhibit in such a marked degree the features of igneous rocks that it was concluded, mainly on the evidence of their structure, that they were original eruptives, i. e., that they both solidified from a molten magma which was derived from some place within or beneath the earth's crust. In the article referred to it was stated that "All the field relations seem to point to the *original* character of the rocks. They occur in dikes and veins intersecting other rocks, and the contact between them and the quartzites which they cut is sometimes clearly seen. It must be confessed, however, that without microscopical and chemical evidence of the identity of these rocks with the quartz porphyry [of the Lake Superior region] their true nature would be difficult to discover from the field relations alone. A more careful examination of the structure of the point, will probably reveal facts which will place beyond doubt the conclusions reached by the microscopical examination."

Since the above was written a second visit to Pigeon Point has been made, but contrary to expectation the relations of the red rock to the gabbro and the quartzites, with both of which it is in contact, appear to contradict the above statements rather than to affirm them.

As indicated in a previous article* the rocks on the point comprise evenly bedded slates and quartzites, a large mass of olivine-gabbro, trap dikes cutting the gabbro and the bedded rocks, and a red granitic and porphyritic rock. The latter occur in large quantity only between the gabbro and a series of contact rocks, which have evidently resulted from the slates and quartzites by alteration. (See map, fig. 1.) The granular rock passes by imperceptible gradations on the one hand into the gabbro, and on the other into the quartzites. From the larger masses of the red rock dikes and veins extend into the members of the contact belt. In a few places large bodies of the same rock have been forced under the unaltered fragmentals and have thrown them into gentle folds. The red rock is found in largest quantity where the contact belt is widest, and is absent from those places in which there are no indications of a metamorphic action in the slates and quartzites.

On the other hand, there are several places on the point where the gabbro and the quartzites are separated by two or more members of the contact belt without the interposition of

* This Journal, May, 1888, p. 388.

any of the red rock. At the falls of Pigeon River, on the north side of the point at its extreme western end, a large mass of gabbro has cut through slates and quartzites and has altered them in a manner somewhat analogous to the alteration of similar rocks by granite and other plutonic rocks.

At other places, notably on the north side of the point, the gabbro and fragmental rocks are in contact without the least trace of any alteration in the latter.

From the relations of the gabbro, the red rock and the contact belt, it is plain that either the gabbro or the red rock is the cause of the contact belt. If the latter, the red rock is a true irruptive; if the former the red rock is either an irruptive between the metamorphosing agent and the products of its action, or is itself one of these products.

It is the object of the present note to point out the reasons that lead the writer to the conclusion that the red rock is of contact origin, that it has been produced by the action of the gabbro upon the slates and quartzites. At first glance it would appear that the evidence is strongly in favor of the red rock as the cause of contact phenomena. This view is apparently favored by the fact that the gabbro has produced no very great alteration in the surrounding sedimentary beds in those localities where no traces of the occurrence of the red rock can be found. It has not affected the bedded rocks on the north side of the point, nor are immense dikes of a similar rock known to have produced any change in the slates and quartzites at other points along the north shore of Lake Superior. If, however, we examine these facts critically it will be found that they do not exclude the possibility of a secondary origin for the red rock, or of the active agency of the Pigeon Point gabbro in promoting the metamorphism of the elastic beds.

The existence of the keratophyre in dikes and veins in the contiguous slates and quartzites show conclusively that it once existed in a plastic condition. Its structure indicates that it once existed as a molten magma, or in such other condition as would allow of its complete crystallization, unless we assume with Wadsworth* and Judd† that the porphyritic and granophyric structures may arise from secondary causes. The impregnation of the contact rocks by the material of the red rock is further evidence that this was once in a liquid state.

If we assume the original molten or liquid condition of the red rock, as it seems we are perfectly justified in doing, all of its present characteristics are explained, whether it be regarded as an extraneous igneous rock or whether it be considered as a final product of contact action. In either case its most charac-

* Geol. and Nat. Hist. Surv. of Minn., Bull. No. 2, pp. 12 and 68.
† Quart. Jour. Geol. Soc., May, 1889, pp. 175–178.

teristic features would be those of a plutonic rock, since the conditions under which it solidified (as shown by the nature of the contact phenomena) are those that give rise to the distinctive features of plutonic rocks. The porphyritic structure noted in a few places must be due to local conditions that prevailed only at a few localities. Under this assumption are explained the intrusion of the keratophyre into the slates, the crumpling of the latter and the alterations effected in those near the sides of dykes of the former, and in fragments included within its mass.

The distribution of the red rock, its occurrence only between the gabbro and the altered quartzite, is the strongest argument in favor of its secondary origin. A glance at the map will

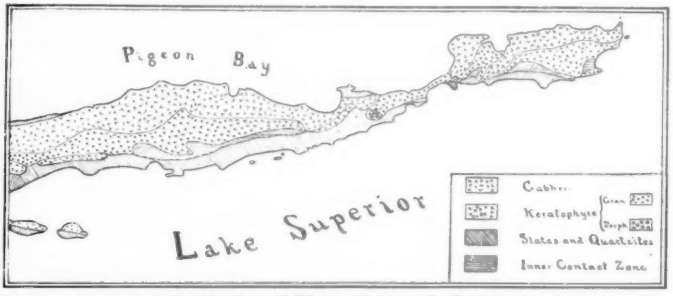

FIG. 1.—Geological Sketch Map of Pigeon Point. Scale 1 in. = about 1¼ miles.

show that the red rock occurs only in areas lying between the gabbro and the members of the contact belt.* At no other places is it found, except in the form of dikes directly connected with the larger masses of the rock. If it can be shown that the contact rocks owe their origin to the presence of the gabbro near them, it will follow as a natural probability that the red rock is likewise of contact origin. Wherever it exists there is on one side of it the gabbro and on the other side two or more members of the contact belt. Its position is that of a member of the contact belt. It follows the sinuosities of the gabbro as no irruptive rock would be likely to do, and is present in greater or less amount according as the contact belt beyond it exhibits contact phenomena in greater or less degree. Where this contact action has been most intense there is found the greatest amount of the red rock; where the action has been less in degree the amount of

* In consequence of the small scale upon which the map is drawn only the zone of most intense alteration is represented on it. The outer zones of the contact belt extend along the entire southern edge of the gabbro and the red rock, throughout all that portion of the point represented in the map.

the red rock decreases until finally none is present. However, when the red rock is wholly absent contact action is yet often marked. One or even more of the contact zones may be present, but that which indicates the most intense action has disappeared. It is plain, then, that the red rock as an independent irruptive is inadequate to explain the whole of the contact belt. On the other hand, the phenomena of distribution of the various rocks are such as would be expected were the gabbro the cause of the existence of the red rock and the contact zone. If the red rock is a result of contact action we should expect to find it between the gabbro and the outer members of the contact belt—in greatest quantity where the other contact effects are best exhibited, and in small quantity where the other contact products are scant in amount. Where the effect of the metamorphosing rock upon the quartzites is very slight, the red rock should be absent.

The great differences in the intensity of the action of the gabbro upon the surrounding bedded rocks may be readily explained by supposing that the orifices through which the rock was extruded were situated at those places where the contact belt is widest, and the red rock is present in greatest amount. In the neighborhood of these orifices, the intruded rocks would have been subjected to the influences of the presence of a molten mass near them for a considerable length of time. Where the contact products are not abundant, the molten gabbro may have escaped from its channel and thrust itself between contiguous beds of the clastic rocks, as is known to be the case in several of the localities where the contact effects are slight.

The presence of a contact belt around the gabbro on Pigeon Point, while it is absent, in most cases at least, from around the dikes of a similar rock abundant in other portions of the Lake Superior region, needs explanation if the view that this rock is the cause of the contact belt in the former locality is to be accepted. It may readily be accounted for by the fact that, whereas, the gabbro along the north shore of the lake is in the form of simple dikes, the rock on Pigeon Point possesses many of the characteristics of a boss.*

That the gabbro upon the point is fully capable of producing contact effects is plainly shown by the existence of contact phenomena at the falls of Pigeon River, and at other places where there is no indication of the presence of the red rock in the vicinity.

The effect of the gabbro upon the quartzites and slates of the point can be studied directly in the inclusions of the latter

* Cf. N. H. Winchell, Ninth Ann. Rep. Geol. and Nat. Hist. Survey of Minnesota, p. 63.

rocks in the former. In those portions of the contact belt nearest the gabbro (indicated on the map by horizontal lining), more particularly in the western portion of the point, there is a band of breccia of varying width. This consists of a cement of gabbro, or of one of the most basic of the intermediate rocks (a mixture of gabbro and red rock),* holding numerous inclusions of slate and quartzite. The slate fragments in this breccia have been altered like the slates in the innermost contact zone. The fragments of quartzite are fringed by a rim which is exactly like the material of the keratophyre. One fragment that shows this red border most beautifully is a rhomboidal block of pink quartzite, about seven feet in length and four feet wide. Surrounding it is a bright red border some two and a half or three inches in width. In the thin section the material of this border is observed to have the granophyric structure of the red rock. Fan-like groups of feldspar and quartz extend perpendicularly from the bounding planes of the inclusions. Since this rim is probably the result of the fusion of the peripheral portion of the fragment by the surrounding rock, and its structure and mineralogical composition are identical with these of the red rock, it may fairly be concluded in the absence of any evidence to the contrary, that the red rock itself has been produced in the same way by the fusion of the quartzites (and slates) by the gabbro.

Moreover, if the red rock is a fused sedimentary, there should be intermediate stages in the transition from a clastic rock to a crystalline one. The red quartzites of the inner contact belt have a structure that can be explained by supposing them to be quartzites whose interstitial feldspathic and chloritic substance has been fused, or by regarding them as fragmental rocks into which the liquid magma of the red rock has been squeezed by pressure. In either case the porphyritic and irregularly outlined quartz crystals so commonly found in these rocks are probably the corroded remains of the original grains of the quartzite. On the top of the porphyry bluff, whose position is indicated on the accompanying map (A), the porphyritic red rock is abundant on the west side of the cliff. As we proceed eastward mottlings are discovered in it that resemble the mottlings characteristic of certain zones of the contact belt. On the extreme eastern side the prevailing rock is an altered red quartzite. No line of demarkation can anywhere be discovered between the different types.

Although these gradations may not serve to prove positively that the quartzites by fusion gradually pass into the red rock, the almost universal presence of transitional phases between the red rock and the altered quartzites in those places where

* This Journal, Jan., 1889, p. 58.

the red rock is present, taken together with the fact that contact rocks are found in positions where they cannot have been produced by the action of the keratophyre, seems to point to this conclusion as the most probable one.

From the evidence at hand it would appear that the red rock is a product of contact action between the gabbro and the bedded rocks, rather than an independent irruptive that has altered the slates and quartzites. No conclusive evidence bearing upon the question is available, but if the assumption of the secondary origin of the red rock is made, all the facts observed with reference to the distribution of the rocks on the point are readily explained; not a single one but is in accord with this supposition. On the other hand, if the red rock is assumed as the metamorphosing agent, there remain to be explained the contact phenomena around the gabbro in those places where the red rock is absent, and the peculiar distribution of this rock. The view that the gabbro is the cause of the alteration of the slates and quartzites, and the red rock is an independent irruptive between the former and the latter, meets with the same objection as does the supposition that the red rock is the cause of the contact belt. The presence of the red rock only between the gabbro and the contact rocks, and in great quantity only when the contact phenomena in the adjacent quartzite evince intense action, is a mode of distribution for an independent irruptive rock, which, to say the least, is peculiar. Since, therefore, objections can be raised to any view that regards the keratophyre as an original irruptive, and since, on the other hand, every fact observed, either with reference to the gabbro or to the red rock, accords with the assumption that the latter is a product of contact action, and none can be found that contradict this supposition, it would seem gratuitous to regard the red rock as having originated in any way but by the fusion by the gabbro of the fragmental rocks that lie upon one side of it. The latter are slates and quartzites, many of which are highly feldspathic. Chemical analyses of these show them to have a composition not very different from that of the red rock itself.

It is hardly necessary to refer to the important bearing of the above conclusion upon the discussion of the origin of igneous rocks. The general view with regard to these is that they have reached the surface from some permanent or temporary reservoir of molten material below the earth's crust. On the other hand, many geologists hold to the belief that some of the igneous rocks have resulted by the metamorphism of sedimentary beds. Granite for instance is regarded as a metamorphosed sandstone. The only basis upon which this conclusion rests is the supposed gradation of gneiss into granite.

No positive evidence of the change of a fragmental into a holocrystalline rock, with the characteristics of an igneous one, is available, except, perhaps, where the former have been affected by dynamo-metamorphism and have been squeezed into the surrounding massive and stratified rocks.*

The red rock of Pigeon Point, however, has a thoroughly crystalline structure throughout its greater part. It occurs as dikes, bending and crumpling beds of other rocks beneath which it has been thrust, and in every other respect acts exactly like the most typical igneous rock. If its origin is indeed secondary, we have in it the first instance in which a fragmental rock can be traced into its corresponding holocrystalline derivative, and we can explain the change without the interposition of the indefinite "metamorphic processes," that are relied upon to explain so many of the difficult problems that arise in the study of rocks.

A detailed description of the rocks of the contact belt and a fuller discussion of the origin of the red rock associated with them, will appear in a forthcoming Bulletin of the U. S. Geological Survey.

Geological Laboratory of Colby University, Dec. 24, 1889.

Art. XXXVI.—*Recent Contributions to Dynamical Meteorology;* by Frank Waldo.

In the American Meteorological Journal for July, 1887, I have mentioned the most important papers that had appeared, up to 1886, on the subject of Dynamical Meteorology. Since then a number of important additions have been made to the literature of the subject, and it is of these that I propose to make a brief mention. While in the above mentioned article there were given only a very few of the three-score papers comprising the whole literature of the subject, in the present list, all of the important very recent papers that have come to my notice are catalogued. Copies of most of these papers were received, from the authors, shortly after their publication, and it was my intention to translate the shorter ones for republication in American journals (as a continuation of the still unprinted Signal Service translations of the Guldberg and Mohn, Oberbeck and Sprung papers), but the information that some of these recent memoirs had already been translated made such a work unnecessary. As, however, not all of the papers in my list will be published in translation, the following remarks may be found of use: and especially to those readers who may be interested in the development of meteoro-

* Reusch: Bommelœn og Karmœn med omgivelser geologisk beskrevne. Kristiania, 1888.

logical theories, but who have not been able to keep informed concerning the appearance of new foreign articles on the subject. As there are so many papers to be mentioned, I have merely endeavored to give a general idea of the nature of each one, and have indicated the attitude of the writers toward meteorology by a slight reference to other work done in this same direction. If I had attempted to give an account of the methods and results of each one, not more than two, or possibly three, of the fourteen papers mentioned here could have been reviewed within the limits of this article; and that would not have shown so clearly as I wished to bring out, the renewal of interest which is taking place concerning progress in the theoretical development of meteorology. Special attention is called to the lack of interest shown on this subject by English and American physicists; at least if we are to judge of the interest by the number of contributions relating to it.

1. Werner Siemens, Ueber die Erhaltung der Kraft im Luftmeere der Erde, Sitzungsberichte d. k. preuss. Akad. d. Wissenschaften, 1886, xiii, (4 März.) 15 pages.
2. Max Möller, Ueber Verluste an äusserer Energie bei der Bewegung der Luft, Meteorologische Zeitschrift. Sept., 1887, 6 pages.
3. Werner Siemens, Zur Frage Luftströmung, Meteor. Zeit. Dec. 1887, 4 pages.
4. Diro Kitao, Beiträge zur Theorie der Bewegung der Erdatmosphäre u. d. Wirbelstürme, Journal of the College of Science, Japan, vol. i, Part II. Tokio, 1887, 96 pages in I Abhandlung.
5. Same title, same journal, vol. ii, 75 pages in II Abhandlung.
6. A. Oberbeck, Ueber die Bewegungserscheinungen der Atmosphäre, Sitzungsberichte d. k. preuss., Akad. d Wissenschaften, Part I, März. 15, 1888 (No. xiv) 13 pages.
7. Part II. Same title, Nov. 8, 1888 (No. xliii), 10 pages, with corrections to Part I.
8. A. Oberbeck, Ueber die Bewegungserscheinungen der Atmosphäre, Naturwissenschaftlichen Rundschau, 1888, 13 pages. (Reprint. Meteor. Zeit. Aug., 1888).
9. H. von Helmholtz, Ueber atmosphärische Bewegungen—Sitzungsberichte d. k. preuss., Akad. d. Wissensch, May 31, 1888. (Reprinted Meteor. Zeit. Sept., 1888, 12 pages).
10. Max Möller, Der Kreislauf der atmosphärischen Luft zwischen hohen und niederen Breiten, die Druckvertheilung und mittlere Windrichtung, aus dem Archiv der Deutschen Seewarte, X Jahrgang, 1887. No. 3, 28 pages.
11. Dr. Vettin, Ueber die Volumina der in die barometrischen Minima und Maxima hinein, und aus denselben herausstromenden Luft, aus dem Archiv der Deutschen Seewarte—XI Jahrgang, 1888. No. 5, 24 pages.

12. Wilhelm von Bezold, Zur Thermodynamik der Atmosphäre Theil I. Sitz. der k. preuss. Akad. d. Wissenschaften, April 26, 1888. (No. xxi). 38 pages.
13. Theil II. Same title. Nov. 22, 1888. (No. xlvi). 18 pages. (Theil I and Theil II reprinted in the Meteor. Zeit. Jun., Jul., Aug., 1889.)
14. William Ferrel, A Popular Treatise on the Winds; New York, 1889, 505 pages.

No. 1.—Meteorologists are very attentive to the ideas put forth by those physicists who have made a world-wide reputation in some other branch of study, and who have at last turned their attention to those branches of meteorology which need the clear insight of genius added to rare knowledge of physics to investigate them if any satisfactory conclusions are to be attained. It is under these conditions that we welcome Siemens's contribution to that branch of dynamical meteorology which on account of the difficulties of treatment has been one of the least satisfactory. Recognizing the solar energy as the initial cause of the great atmospheric motions, the author applying the principles of rotation velocity and *living force*, by methods more nearly represented by the conception of the potential of force, reaches conclusions that are in the main coincident with those found by Professor Ferrel in his studies of thirty years ago. The physical conditions which give rise to various special phenomena of rainfall have been treated in a general way in explanation of such features as the rainfall in the temperate zones. It seems that Siemens has given his views without having made himself thoroughly acquainted with the results already obtained by previous workers in this same field, and that he was not familiar with many of the points stated by Sprung in the excellent summary given in his Lehrbuch. As it is, some of the ideas which the author advances as novel have already been more or less satisfactorily treated by others. Still, such questions as the origin and maintenance of barometric maxima and minima, and the mechanics of spout phenomena, need further treatment, and every new view, if based on accepted principles, is a help toward the final discovery of the actual truth, which cannot be said to be reached at the present time.

No. 2.—The paper of Siemens just mentioned called forth this short, but practically important communication from Max Müller. (Mr. Müller is a young engineer of Hamburg who has written several very suggestive semi-popular papers on the mechanics of the lesser atmospheric motions, and which have shown an unusual grasp of the subject). In the present paper the author calls attention to the important factor which the loss of living force by friction of the air in contact with the rough

earth may become in the formation of the atmospheric motions. The frictional influence of rough ground is more or less pronounced according to the peculiarities of the air currents; whether they are ascending, descending, or horizontal. The author investigates this action in some general types of circulation. He contrasts the peculiarities of two continental atmospheric depressions; in the one an upward current preponderates, while in the other a downward current is the ruling one. In the first case, the one in which the depression has a warm center and an upward current, the relatively quiet air near the surface of the earth carries with it no great force and in fact has a retarding influence on the upper currents; and in the second case, where the depression has a cold center and there is a downward current, the feeding current easily acquires a great velocity. These two conditions cause very different results, and the author brings out these differences. It must be remembered that Ferrel first pointed out that at the poles there is a depression of the second class, and that the great movements of the masses of air to the eastward in middle latitudes are but a part of this great system. The author, however, thinks that Ferrel has not sufficiently considered the effects of friction, and he modifies Ferrel's numerical results so much that in some cases he reverses the latter. Treating of the mixing of air masses having different velocities the author does not agree with the results obtained by Siemens in No. 1. He thinks that the transmission of force does not take place according to the law of preservation of living force, when we wish to compute the resulting velocity, but it follows the law of inelastic impacts. This he proceeds to illustrate by a short computation.

No. 3.—This article was called out by Möller's strictures in No. 2 against Siemens's methods in No. 1. Siemens thinks that Möller's conceptions are wrong as to the waste of force by friction, and assumes that the layers of air close to the earth are in relative rest, and the thickness of this layer depends on the roughness of the surface; while the upper air layers are practically free from these frictional influences. As regards the mixing of currents having different velocities, Siemens shows that his assumption concerning this question does not affect his general results; and as for Möller's use of the theory of inelastic impacts, he merely remarks that the necessities of the question do not call for its consideration. Siemens regards the coincidence between his and Ferrel's views of the atmospheric motion in the neighborhood of the 35th parallel as accidental, as Ferrel has not considered the inertia or the friction, while he (Siemens) has taken into consideration by computation the final condition of equilibrium. Siemens

thinks that an important reason for the incompleteness of Dove's theory was that the doctrine of the conservation of force had not then been established The author then proceeds to account for the low pressure at the poles, and also the formation of "maxima" and "minima" and other local differences of air pressure.

No. 4 and *No. 5.*—Dr. Kitao, the author of these two papers, which are really a single memoir published in two parts, is professor of physics and mathematics in the Imperial Academy of Forestry and Agriculture at Tokio. I have not been able to obtain a copy of No 4 (Part I.), and can therefore, give only a surmise as to the value of this portion, basing my views on an examination of No. 5 (Part II.). It was with curiosity, which however rapidly changed to surprise and admiration, that I took up this paper. Coming as it does from a Japanese, whose name had not been previously connected with meteorology (so far as I am aware), this paper, treating of the most difficult branch of meteorology in such a manner as to place it in the front rank among those in which the principles of mechanics are applied to the motions of the atmosphere, should receive the careful attention which it deserves. The method of reasoning adopted by the author is one that would naturally commend itself to a mathematical scholar who had mastered modern methods of hydrodynamical analysis, such as is to be found in the works of Thomson and Tait, and a few Continental text books. While I am not prepared to enter into details as to my reasons for thinking so, yet it appears to me that although this paper is probably of great theoretical value, and it will be found very suggestive to the student of meteorology, yet its full practical value has yet to be shown. As a logical mathematical development of the general theory of the motions of an atmosphere it is certainly a remarkable chain of reasoning. In No. 5 (Part II.) no mention is made of what has been done by other investigators in the same field, and in fact the author seems to have worked out the whole matter for himself. The methods of analysis certainly show great originality of conception and adaptation, and it is to be hoped that the whole paper will soon be republished in some form accessible to a wide circle of students. Unfortunately, however, so far not even a review of the work has been given to meteorologists. The divisions of No. 5 are as follows: Chapter VIII, Regions of whirls for straight-lined isobars; chapter IX, plurality of whirl formations in the earth's atmosphere; chapter X, motions of the region of whirls itself; chapter XI, change in the wind direction, wind force and the air pressure, for a given exterior point for a double formation of whirls. There is space here only to mention one or two of the results obtained

by the author. He finds, for example, that "if two cyclones are formed in the atmosphere they will mutually approach each other, since they rotate in a cyclonal direction about a definite point at rest; while two anti-cyclones on the contrary separate, as they rotate in an anti-cyclonal direction about a definite point." In the last chapter are numerous conclusions that will be of great value if they can be found to hold good in the actual conditions of the atmosphere. (I hope to give an extended review of this whole memoir when I can secure a copy of the first portion.—F. W.).

No. 6.—Professor A. Oberbeck has rendered important service to several branches of physics. His papers on electricity, fluid motion (and other conditions of fluids), and atmospheric mechanics, are all in the front rank of such investigations. In 1882, Prof. Oberbeck published a very important paper in Wiedmann's Annalen with the title, "Ueber die Bewegungen der Luft an der Erdoberfläche," but I think he had not published any other important paper on meteorology until the present contribution appeared; the author, in the meantime, having gone from the university of Halle to that at Griefswald.

In the present paper the author refers to the progress that has been made in the study of atmospheric mechanics during the past ten years, and remarks that although some special points have been satisfactorily treated, as is shown by the excellent résumé given in the *Lehrbuch der Meteorologie*, written by Dr. A. Sprung, yet no complete theory can be deduced until we have a better knowledge of the upper air currents. He says, however, that "The outlines of a rational mechanics of the atmosphere are given in the paper of W. Siemens, "Die Erhaltung der Kräfte in Luftmeere der Erde," (which is No. 1, of the memoirs we are now considering), and thinks it would be well to give a further mathematical development of the theory outlined in that brief paper. On account of the great difficulties to be encountered in any general solution of the problem with all the secondary phenomena, the author limits himself to the computation of the air currents, to the exclusion of such questions as "pressure," distribution, etc. A statement is then made of the various causes of atmospheric motions: temperature, influence of the earth's rotation, friction. Concerning this last, he says that the theories that have heretofore taken into account the friction have not been properly constructed, and that according to his view the law of friction for atmospheric currents is the same as has been developed for fluid motions, *but* the laboratory numerical coefficients cannot be applied without great modification, according to the different

conditions to be found in the actual atmosphere. The author's views of the limiting conditions that must be made in the statement of the hydrodynamics of the problem are of the utmost importance. The suggestions concerning the representation of the temperature distribution by means of spherical functions (this was beautifully worked out by Schoch about 1856) should receive the careful consideration of students of meteorology. At the end of the paper is given a general outline of: 1, currents in the case of a spherical earth without rotation; 2, currents arising in consequence of the rotation of the earth.

No. 7.—This is a continuation of the previous paper. In the latter the "pressure" distribution was not considered except incidentally. In this paper he takes up this question and comes to the conclusion that the existing pressure distribution is fully explained by the currents of the atmosphere, and that from the observed values of the pressure, we can draw conclusions as to the intensity of the air currents.

The author then deduces a general view of the pressure distribution at the earth's surface and in elevated regions. The intensity of the rotation currents, both at the earth's surface and up above, is next considered; and this necessitates the introduction of the equation of continuity which plays an important part in the analysis which follows. After stating a formula which represents, with tolerable accuracy, the change of air pressure (at the earth's surface) with the latitude, the author proceeds to calculate the angular velocity of the rotational motion of the air, by means of the formulæ developed by him. After drawing some general conclusions in regard to the actual circulation of the atmosphere, and in which the vertical components receive special attention, the author closes with some most important suggestions concerning the lines for future investigations on this same subject.

No. 8.—This paper is stated by the author to be a popular account of No. 6, and which he prepared at the request of the editor of the "Rundschau." In attempting to make the matter clear, he has entered into such details (which he evidently considered unnecessary in No. 6) that the present paper can hardly be called an abstract of a former one, but must be considered a separate contribution. He has given a short summary of what other workers have done toward creating an atmospheric mechanics, and his ideas deserve special consideration coming as they do from one of the most skillful of the present contributors to the science of mathematical physics. Recognizing that Ferrel was the first to give even an approximate solution of the problem of atmospheric circulation, he goes on to criticize in some respects the method employed

as compared with the more finished analysis of the present ideas of fluid and vortex motion. The works of Guldberg and Mohn are also referred to: the author also calling special attention to the estimate Sprung has given, in his "Lehrbuch," of these writers, and particularly of Ferrel's work. Next he gives an outline of the methods used in his own paper (No. 6) and explains with greater clearness the part friction plays in the whole matter of fluid motion. Finally, he gives a rough chart, on the Mercator's projection, of the air currents for the lower layers as deduced by his theory.

No. 9.—Professor von Helmholtz, who has done so much for the advancement of other branches of physics, has at last given some attention to a problem in every way worthy of his consideration, viz: Atmospheric motions. The author's well known investigations on fluid motion have been used as a basis for other contributors to work from, but I believe he has himself published only one other paper, and that of a popular nature, which deals with a specially meteorological topic.

In the present paper the author treats: § 1, The influence of friction on the great circulations of the atmosphere; § 2, Rings of atmosphere having different temperatures and rotation due to the equilibrium; § 3,* Adjacent layers in equilibrium, and having different values of ϑ and Ω; § 4, Gradual changes of equilibrium through friction and warming up.

By aid of the potential, the author derives the equations of fluid motions taking into consideration the friction. The integration of these equations cannot be accomplished until certain constants have been determined. A very neat comparison is made of the two methods of determining the friction constant, viz: in the laboratory, and in nature. There are not data for the latter for high elevations but some valuable ideas are given, which the theory shows must hold good. These relate to change of friction with distance from the ground, differences of pressure and differences of temperature. The author then applies his reasoning to several rings of atmosphere encircling the globe at various latitudes, but finds that other influences must be considered, before the observed facts can be explained. In § 2, the method of determination of the calm belt, toward which the "pressure" increases both from the pole and from the equator, is of great importance. In § 3, the conditions of equilibrium, as determined by the heat capacity of the different layers, are worked out in a very general way; and the form of the layers is shown for various cases. The position is also given of the layers in the case of continual change of the velocity of rotation with the heat capacity. The § 4 contains

* ϑ is the temperature of the air under pressure p_0. Ω is the moment of rotation (which remains constant under certain assumed conditions).

the most practical ideas of the paper, and the author calls attention to several points that will receive the consideration of even the non-mathematical meteorologist. The manner in which the air is gradually warmed up by convection is briefly described, and the effects of a warm layer above (as well as below) are pointed out. The modifying effects of friction where layers of different velocities are mixed are examined; and many of the observed facts connected with the general circulation are briefly accounted for. Special attention is also called to the application of the theory of discontinuous fluid motion which was elaborated by the author in the paper presented to the Berlin Academy in 1868. The importance of the application of these ideas to meteorology has been repeatedly pointed out by several meteorologists, but the advice has been little heeded because it is so difficult a question to handle. The author promises a further treatment of the subject, which will be eagerly watched for.

No. 10.—This is by far the most elaborate contribution Mr. Möller has made to meteorological science, and as it is the result of seven or eight years of study of the questions considered, it deserves a careful reading. The following headings of sections show the great number of special topics treated: Introduction (in which he shows the difficulties in the way of the satisfactory application of general theories like Ferrel's); 1. The deviatory force of the earth's rotation; 2. The surfaces of equal pressure, and the horizontal differences of temperature; 3. The location of the surfaces of equal pressure in the earth's atmosphere; 4. Ferrel's explanation of the cause of a maintenance of steep inclination of surfaces of equal pressure in the temperate and cold zones of the earth's atmosphere; 5. Ferrel's computations; 6. The performance of the work produced by the differences of temperature in the atmosphere; 7. The facts concerning the existing air circulation; *a.* The air circulation of the hot zone in general; *b.* Representation of the air circulation in the hot zone, based on numerical calculations; *c.* The belt of the higher pressure; *d.* The air circulation in the temperate zone for the year, also in the Arctic zone in summer; *e.* Phenomena of changing motions in the atmosphere; *f.* The calm zones at the equator; *g.* The Arctic zone in winter; *h.* The amount of work performed in different upper air layers; *i.* Combination of the results, 8. Closing remarks. Illustrations. A postscript of three pages contains some items omitted from the main paper and also some remarks on Ferrel's and Oberbeck's recent works.

While most of the papers by the writers mentioned in this review have been analytical in character, the present one is synthetical, and the author has necessarily been obliged to give

strict attention to the actual facts as observed in nature. He is particularly gratified to find an agreement between some of his views and those given by Oberbeck.

Sections 2, 3 and 6 are of special importance as the topics treated therein are seldom written about. Section 7 presents the author's ideas of the general circulation; and the main interest in the paper, so far as actual results are concerned, will be found centered in this section. The chart of a vertical section of the atmosphere (in the plane of the meridian) in the region of the equator, and extending to a height of 25,000 meters above the sea level, shows with great clearness the author's ideas concerning the circulation in these important regions.

No. 11.—Dr. Vettin of Berlin has long been a special observer of the motions of the atmosphere in the upper layers. As a cloud observer he deserves to rank with Clement Ley, the English observer of whom it is said, he devotes one-third of his entire time to observing the aspects of the clouds. Until the quite recent trigonometrical determinations of cloud elevations and velocities, the long series of observations on the apparent velocities of clouds and their vertical distribution, was the most important carried on by any single observer. The results of these observations have been published in the Österr. Zeits. für Meteorologie, and together with the results of some most interesting experiments relative to the motions of air in a confined space, form the principal earlier meteorological contributions by the author. The present paper is a continuation of some later work published in the Meteor. Zeitsch. in 1887, and while he gives a résumé of his methods of observation and the cloud formations and projected velocities for various elevations as found by him, yet he devotes most of the paper to the consideration of the very important question of the amount of air actually taking part in the in and out flow which takes place in barometric minima and maxima. Very complete tables are given, for summer and winter, in which the sums of the wind velocities as shown by the upper cirrus, the lower cirrus, cloudlets, the rounded clouds, the lower layer of clouds and the wind (anemometrically observed), are given for the 8 octants of both maxima and minima. The same is then presented for the volumes of air (i. e. the product of the times into the velocities). Then follow tables giving these results classified as inflowing or outflowing air. Of special importance are the author's computation of the elevation of the regions of the inflow and outflow of air. This having been previously (so far as I am aware) been made a matter of quite arbitrary assumption in the theoretical considerations made by various writers. The final pages of the paper are

given up to a statement of the author's views as to what effect the shifting of the "cold" pole has on the oscillations of the greater currents. A set of 57 diagrams illustrates in a very acceptable manner, the results found by the author.

No. 12.—Professor von Bezold occupies the chair of meteorology at the University of Berlin, and he gives promise of elevating the Prussian Meteorological Institution to as high a rank among the great national meteorological services as that of the Bavarian Institution among the smaller ones of similar aims. Aside from his officially published papers, he has not printed many memoirs on meteorological topics, but those he has given us are of real value.

In the present paper there is considered a question of meteorological physics that is of the very highest importance in connection with the theories of storms, and of the greater cyclonic and anticyclonic atmospheric movements. A number of writers have treated the question of the application of the mechanical theory of heat to atmospheric events, but in nearly every case only such points have been considered as do not take into account the addition or loss of heat during the expansion or compression. Such treatments of the convective equilibrium of the atmosphere, the unstable equilibrium in the case of tornadoes, and the foehn phenomena, have been made on the supposition of adiabatic changes of condition. The author thinks that the method of research which we owe to Clapeyron and Carnot, and which has been so fruitful in the application of the mechanical theory of heat to the study of machines, should likewise be introduced into meteorological analysis.

Hertz, in a paper in the Met. Zeits. 1884, has made a good beginning in the direction in which the author leads us, but he has considered only special cases; and while his application of the graphical method simplifies the question very much, yet it does not take the place of the more general analysis when the wide application of the principle is to be considered. Sprung, also, in his "Lehrbuch" lays stress on the ideas given in Hertz's paper. In the present paper the author explains at length that the cooling and warming up in the case of ascending and descending currents in the atmosphere are to be considered only as a result of the work of expansion and compression, but not the work, which is used in raising the air, and is obtained by the falling, when rising and falling masses did not always belong to a system. The work of expansion and compression must not be omitted from the calculations, as has been done in the computations of Guldburg and Mohn.

The "equations of mixture" are then determined for the four atmospheric stadia, viz: dry stratum, rain stratum, hail stratum, and snow stratum. Then the equations of the char-

acteristic curves are deduced. These are the isothermic, adiabatic, and curves of constant amount of saturation. A short application is then made to the "foehn," and the interchange of air between cyclones and anticyclones in summer.

(There is a considerable literature treating of the matter of convective equilibrium, but I cannot make special mention of it here. I will only mention that in Maxwell's elementary "Theory of Heat" (1880) there is to be found a popular explanation of several important points in this connection.—F. W.)

No. 13.—While this paper is in one sense a continuation of the preceding, yet the introduction of new conceptions, the chief one of which is what Helmholtz has termed "Wärmegehalt," but which, after considering the objections made by von Bezold to this nomenclature, he now prefers to call "potentielle Temperatur." This potential temperature is that absolute temperature which a body assumes when it is brought under the normal pressure without gain or loss of heat—adiabatically or pseudoadiabatically. The graphical determination of potential temperature corresponding to any given condition is very neatly worked out for the dry stadium. In the case of condensation the potential temperature rises and becomes the greater the larger the amount of water lost out. Also "adiabatic changes of condition in the free atmosphere—excluding, however, evaporation—leave the potential temperature either unchanged or they elevate it." The author calls attention to the similarity between this and the theorem of Clausius concerning entropy.

The next section treats of the vertical temperature gradients, and the author emphasizes the fact that the thermodynamic cooling and heating in consequence of the expansion or compression in ascending or descending currents plays a most important part in the vertical motions of the atmosphere. So long as we consider the free atmosphere in which there is little opportunity for the absorption or emission of heat and where only approximate results are expected, we may consider only the adiabatic conditions; but in the neighborhood of the ground and in the regions of cloud or fog the conditions are such that this method is no longer satisfactory.

The author illustrates by a diagram what he calls his "normal plan" of ascending and descending currents; and in it he shows the relation of the ascending current in the dry stadium, its continuation in the stadium of condensation, and finally the curve corresponding to the descending current. The application then shows the practical application to the interchange of air between cyclonic and anti-cyclonic systems, and some more special cases; next follow over half a dozen pages giving the application of the idea of potential temperature to various

states of the atmosphere, the deductions of some theorems, and some instances of their use. These theorems are sure to be of the greatest service in perfecting a theory of the vertical interchange of air masses. A couple of pages also are devoted to the subject of compound convection. The author closes with some remarks on the importance of these ideas to any future development of the subject; and he makes some corrections to his first paper (No. 12).

No. 14.—Professor Ferrel's contributions to meteorology are too well known to the readers of this journal to require cataloguing. His book on "Recent Advances in Meteorology," published as Part II of the Chief Signal Officer's Ann. Report for 1885, contains for the most part a connected statement of the results of his meteorological labors during a period of about thirty years. This work was most acceptable to students of meteorology because it gave in a single volume results of the authors researches and the methods by which they were reached, and in addition gave explanations of some points not usually touched on in meteorological treatises.

In the early part of 1886 Professor Ferrel gave a series of forty lectures before a class of Signal Service officers at Washington, and this was the first and only time (so far as I am aware) that he has given a personal systematic explanation of his theories. Recognizing the value of these lectures the Signal Service authorities, I believe, made an unsuccessful attempt to have them written down by a stenographer. A number of Professor Ferrel's friends urged upon him the importance of his giving the substance of these lectures to a wide circle, and in compliance with their requests he prepared the present volume. The contents of the volume are shown by the following chapter headings: I. The constitution and nature of the atmosphere; II. The motions of bodies relative to the earth's surface; III. The general circulation of the atmosphere; IV. Climatic influences of the general circulation; V. Monsoons, and land-and-sea-breezes; VI. Cyclones; VII. Tornadoes; VIII. Thunder storms. Taken as a whole the work gives a connected logical explanation of the cause of the greater and lesser atmospheric motions; and, as only very simple mathematical reasoning is introduced in a few necessary places, the book can be understood by the general reader. Every teacher of physical geography, and of physics in general, should read this volume, and no library should be without it. We must consider it as the best and latest statement of the views of Professor Ferrel, who has probably done more than any other one person toward establishing a science of meteorology.

Cincinnati, Jan. 1890.

P. S.—Since writing the above I have come across the following titles, but have seen only one of the papers:

Pernter, Die allgemeine Circulation der Atmosphäre. Wien. 1889.
Köppen, Ueber die allgemeine Circulation der Atmosphäre. Humboldt, Dec., 1888.
Marchi, Saggio d'Applicazione dei Principii dell' Idraulica alla Teoria delle Correnti dell' Aria. Rome, 1889.
Roth, Der Einfluss der Reibung auf die Ablenkung der Bewegungen längs der Erdoberfläche, Wochens. f. Astron., 1886 (modified by communication written in 1888).

The recent treatises of Blanford and Abercromby should perhaps also be mentioned in this list.

ART. XXXVII.—*Two Methods for the Direct Determination of Chlorine in Mixtures of Alkaline Chlorides and Iodides;* by F. A. GOOCH and F. W. MAR.

[Contributions from the Kent Chemical Laboratory of Yale College—II.]

THE determination of chlorine associated with iodine in haloid salts is usually accomplished by differential or indirect means: either the two halogens are determined together in a portion of the assay while the iodine alone is estimated in a second portion by one or other of well known methods, the difference between the sum of the halogens and the iodine being the chlorine sought; or, the silver salts of the halogens are weighed together and then converted into a single salt, or the metal, the ratio of chloride to iodide in the original salt being found by simple algebraic processes. If the amounts of iodine involved are minute, it is possible to separate that element by Fresenius's method of treatment with nitrous acid and a solvent like carbon disulphide, and then to determine chlorine directly in the residue; but the manipulation of the process is difficult, and the results inaccurate, when much iodine must be removed. The only method which has been deemed generally applicable to the direct estimation of chlorine associated with iodine in haloid salts is based upon Lassaigne's reaction, by which the iodine is precipitated as palladious iodide; but, the necessity of removing the excess of palladium by hydrogen sulphide before proceeding to precipitate the chlorine is so irksome that, even in this process, it is found to be more convenient to fall back upon the estimation of chlorine as the difference between the iodine found by the palladium process and the sum of the iodine and chlorine obtained by another test in another portion of the material.

A straightforward and easy method for determining the chlorine is obviously desirable, and in the work of which we here give an account we have endeavored to find such an one.

It is a well-known fact* that when an aqueous solution of hydrochloric acid is boiled a point of concentration is reached, by the excessive loss of acid from stronger solutions and of water from weaker ones, at which, for definite barometric pressure, the liquid boils at a constant temperature and distils unchanged in composition. It follows naturally that a degree of dilution may be reached beyond which the loss of the acid must be inappreciable. Indeed, Fleischer justifies his use of hydrochloric acid as a standard in alkalimetric processes upon his observation that decinormal solutions of this acid, and even solutions of twice the strength (7·3 grms. to the liter), do not yield after ten minutes' boiling enough acid to redden blue litmus paper held in the steam. Hydriodic acid behaves similarly to hydrochloric acid in the matter of volatilizing from aqueous solutions; but to the decomposing action of oxidizing agents it is far more sensitive. Our endeavor has been to find conditions under which hydriodic acid may be completely broken up, and its iodine removed from the solution by vaporization, while the hydrochloric is retained without appreciable loss. As a first step toward the solution of this question we initiated a series of experiments upon the volatility of hydrochloric acid in solutions containing sulphuric acid, having fixed upon the latter as the most available means of liberating hydrochloric and hydriodic acids from their compounds with the alkaline metals. After a few preliminary experiments with litmus paper exposed in the steam from boiling solutions, we settled down upon two modes of investigating this point. According to the first, the determination of the chlorine remaining after concentration in solutions made up of water, sulphuric acid, and known amounts of the chloride, by precipitating as silver chloride, filtering the precipitate on asbestos, and weighing, was made the test of volatility of the hydrochloric acid; in the second, the same object was accomplished by estimating the chlorine escaping from the solution, by passing the steam through a condenser and precipitating the acid in the distillate by means of silver nitrate, collecting and weighing the silver chloride as in the former method.

The experiments of Series A to Series F were carried out according to the first method. In them portions of a dilute solution of potassium chloride of known value were measured from a burette into Erlenmeyer flasks of 500 cm^3 capacity, sulphuric acid diluted one-half was added, and the solution was boiled until the flask and contents removed from the flame

* Roscoe and Dittmar, Quart. Jour. Chem., xii, 128.

and placed upon counterpoised scales just tipped the beam. A few trials sufficed to bring the weight to the required point, and the degree of concentration was determined by this means far more accurately than by lowering the level of the liquid to marks placed upon the flasks. The hydrochloric acid remaining after concentration was determined as described, the comparison of the result with the value of the standard solution of chloride indicating, of course, the total loss in the process.

In the experiments of Series A, B, C, D, the effect is traced of increasing proportions of chloride as compared with the same amount of sulphuric acid taken. In those of Series C, E, F, the influence of changing proportions of sulphuric acid, while the amount of chloride remains the same, is brought out. In both sets the evidence is plain that the volatility of the hydrochloric acid is dependent upon the proportion of sulphuric acid as well as upon the amount of the chloride present. It appears likewise that when the amounts of sulphuric acid present are reasonably small the loss of hydrochloric acid is inconsiderable, if the concentration is not pushed to too great an extreme.

SERIES A.

Taken H_2SO_4 [1:1].	Taken KCl = HCl.		Found AgCl = HCl.		Initial volume.	Final volume.	Error.
cm³	grm.	grm.	grm.	grm.	cm³	cm³	grm.
10	0·05	0·0245	0·0963	0·0245	110	65	0·0000
10	0·05	0·0245	0·0957	0·0243	110	45	0·0002—
10	0·05	0·0245	0·0945	0·0240	110	40	0·0005—
10	0·05	0·0245	0·0941	0·0239	110	35	0·0006—
10	0·05	0·0245	0·0871	0·0221	110	30	0·0024—
10	0·05	0·0245	0·0821	0·0209	110	25	0·0036—

SERIES B.

10	0·1	0·0489	0·1910	0·0485	110	65	0·0004—
10	0·1	0·0489	0·1922	0·0488	110	55	0·0001—
10	0·1	0·0489	0·1908	0·0485	110	45	0 0004—
10	0·1	0·0489	0·1894	0·0482	110	35	0·0007—

SERIES C.

10	0·2	0·0978	0·3837	0·0976	110	75	0·0002—
10	0·2	0·0978	0·3838	0·0976	110	65	0·0002—
10	0·2	0·0978	0·3831	0·0974	110	55	0·0004—
10	0·2	0·0978	0·3816	0·0970	110	45	0·0008—
10	0·2	0·0978	0·3746	0·0953	110	35	0·0025—
10	0·2	0·0978	0·3322	0·0845	110	25	0·0133—

SERIES D.

Taken H_2SO_4 [1:1].	Taken KCl=HCl.		Found AgCl=HCl.		Initial volume.	Final volume.	Error.
cm³	grm.	grm.	grm.	grm.	cm³	cm³	grm.
10	0·4	0·1956	0·7690	0·1955	110	60	0·0001—
10	0·4	0·1956	0·7682	0·1954	110	50	0·0002—
10	0·4	0·1956	0·7574	0·1926	110	35	0·0030—
			SERIES E.				
5	0·2	0·0978	0·3845	0·0978	105	55	0·0000
5	0·2	0·0978	0·3838	0·0976	105	45	0·0002—
5	0·2	0·0978	0·3823	0·0972	105	35	0·0006—
5	0·2	0·0978	0·3788	0·0963	105	25	0·0015—
			SERIES F.				
20	0·2	0·0978	0·3782	0·0962	120	75	0·0016—
20	0·2	0·0978	0·3602	0·0916	120	65	0·0062—
20	0·2	0·0978	0·3087	0·0785	120	55	0·0193—
20	0·1	0·0978	0·2931	0·0745	120	45	0·0233—

The quantities of chloride dealt with in the preceding experiments are rather smaller than those which would naturally be handled in practical analysis, so that it seemed best to extend the experimentation to solutions of greater dilution and containing larger amounts of chloride. In the experiments of Series G, and subsequently, the second mode of treatment referred to was adopted. The flask was filled as before, but was connected with an ordinary glass condenser so that the distillate might be collected and measured, and the hydrochloric acid condensed with the steam was estimated by precipitation as silver chloride, the last being dried and weighed as such upon asbestos. The details of the experiments are given in the tabular statement.

SERIES G.

Taken H_2SO_4 [1:1].	Taken KCl = HCl.		Initial volume.	Final volume.	Time in minutes.	Found AgCl.	Loss of HCl.
cm³	grm.	grm.	cm³	cm³		grm.	grm.
10	1	0·4888	400	300	29	0·0005	0·0001
10	1	0·4888	400	300	22	0·0008	0·0002
10	1	0·4888	350	300	10	0·0004	0·0001
10	1	0·4888	350	300	9	0·0005	0·0001
10	1	0·4888	300	200	25	0·0008	0·0002
10	1	0·4888	200	100	27	0·0021	0·0005
10	1	0·4888	100	50	20	0·0037	0·0009

It is obvious from these results that a solution containing 10 cm³ of the 1:1 sulphuric acid, or 5 cm³ of the strong acid, may be concentrated to 200 cm³ without significant loss of

hydrochloric acid. At a concentration of 100 cm^3 the loss is notable. In later experiments, we found that a small part of the precipitate which we weighed in these experiments must in reality have resulted from the action of the solution upon the rubber stopper and connectors of the apparatus; for the distillate from pure water in the same apparatus yielded a precipitate, probably silver sulphide, which filtered off and weighed, was found to amount to 0·0003 grm. The figures of Series G, therefore, overstate somewhat the volatility of hydrochloric acid under the circumstances, but the misrepresentation is inconsiderable. We fixed upon 300 cm^3 as a convenient volume of liquid to manipulate in future experiments, and one sufficiently dilute to guarantee security against the volatilization of hydrochloric acid when the amount of sulphuric acid does not exceed 5 cm^3 of the strong acid, and when the quantity of potassium chloride present does not exceed 1 grm.

The next point to be considered was the proper mode of breaking up hydriodic acid and volatilizing the iodine thus set free, while leaving the hydrochloric acid fixed.

The use of dihydrogen potassium arseniate, which has been utilized to liberate iodine according to a method recently developed in this laboratory,* is precluded by the necessarily high degree of dilution of the solution employed. The first trials were made, therefore, with ferric alum to act as the oxidizing agent according to the well known reaction of Duflos:

$$2H\text{-}I + Fe_2(SO_4)_3 = 2FeSO_4 + H_2SO_4 + I\text{-}I$$

We found by experiment that from a volume of 300 cm^3 containing 10 cm^3 of sulphuric acid [1:1], 5 grms. of ferric alum, and 0·005 grm. of potassic iodide, every trace of iodine had disappeared so completely after five minutes' boiling that nitrous acid and chloroform collected no color in the cooled liquid. It transpired, however, that when the amount of potassium iodide was increased to 1 grm., iodine was found in considerable amount after boiling for an hour with occasional replacing of the water evaporated, so that the volume should not decrease much below 300 cm^3. The failure of the iron alum to expel the iodine is not attributable to a deficiency in amount; for the 5 grm. present were capable of decomposing more than a gram and a half of potassium iodide were the full effect theoretically possible attained. Furthermore, special tests in which the amount of ferric alum was increased developed the fact that the increase was but little helpful. The apparent explanation of the phenomenon is that here, as in the liberation of iodine by means of dihydrogen potassium arseniate, there

* Gooch and Browning, this Journal, vol. xxxix, p. 188.

occurs a time in the course of action when for a given degree of dilution an equilibrium is established between the tendency of the oxidizer to oxidize and that of the reduced residue to reverse the action. The obvious modes of securing completed action are the concentrating of the liquid and the reinforcing of the oxidizer. Application of the former is precluded by the danger of volatilizing hydrochloric acid; the simplest mode of realizing the latter—and as the result proved, a feasible one—is the re-oxidation of the reduced ferrous sulphate by means of nitric acid.

When a sufficient amount of nitric acid is added to restore the iron to the ferric state, the boiling of the solution resulted in the complete liberation of the iodine. In dilute solutions the amount of nitric acid necessary to oxidize a fixed quantity of ferrous salt is greater than in concentrated solutions. Thus, while 0·1 cm^3 of strong nitric acid should be more than enough to reoxidize the iron reduced by 1 grm. of potassium iodide when the full oxidizing action is brought out, we found it necessary to add to the dilute solutions with which we worked about 2 cm^3 of the acid to complete the action satisfactorily. Incidentally, we found that the nitric acid by itself—that is, without the presence of the iron salt—is not effective in liberating the iodine; for, the successive addition of portions of 1 cm^3 of nitric acid to a solution containing 10 cm^3 of sulphuric acid [1 : 1], and 1 grm. of potassium iodide in a total volume of 400 cm^3 until the amount of nitric acid reached 5 cm^3, the liquid boiling all the time, liberated but little iodine, while the addition at this point of 2·5 grm. of ferric alum determined the evolution of iodine in dense fumes.

The addition of 2 cm^3, or at the most 3 cm^3, of strong nitric acid to solutions constituted as has been described proved to be sufficient to liberate the entire amount of iodine present. The question as to whether the hydrochloric acid is affected by the addition of so much nitric acid was settled in the experiments of the following series. In these determinations a little sulphurous acid was added to each distillate to insure the complete precipitation of the chlorine by silver nitrate, and sufficient nitric acid was added to re-dissolve the silver sulphite thrown down also at first.

It appears in these results that the ferric salt has no perceptible influence upon the hydrochloric acid, and that the presence of nitric acid within reasonable limits does not sensibly increase the loss of hydrochloric acid which takes place under conditions otherwise similar, strong nitric acid to the amount of 5 cm^3 in a total volume of 300 cm^3 producing no apparent increment of loss from half a gram of hydrochloric acid. The nitric acid itself passes easily into the

distillate. That the influence of the sulphuric acid is important, is again demonstrated in the experiments in which 1 cm³ of nitric acid and 1 grm. of potassium chloride were distilled in the one case with, and in the other without, the addition of sulphuric acid.

SERIES H.

Taken H_2SO_4 [1 : 1]	Taken Iron Alum.	Taken HNO_3 Sp. Gr. 1·40	Taken KCl = HCl.		Initial volume.	Final volume.	Time in minutes.	Found AgCl.	Loss of HCl.
grm.	grm.	cm³	grm.	grm.	cm³	cm³		grm.	grm.
--	--	1	1	0·4888	200	100	30	0·0006	0·0002
--	--	1	1	0·4888	100	50	14	0.0010	0·0003
--	--	1	1	0·4888	50	15	10	0·0049	0·0012
10	--	1	1	0·4888	200	100	27	0·0031	0·0008
10	--	1	1	0·4888	100	50	16	0 0116	0·0029
10	5	0·1	1	0·4888	400	300	24	0·0004	0·0001
10	5	0·3	1	0·4888	400	300	30	0·0004	0·0001
10	5	0·5	1	0·4888	400	300	30	0·0004	0·0001
10	5	1	1	0·4888	400	300	27	0·0010	0·0003
10	5	1	1	0·4888	300	200	33	0·0007	0·0002
10	5	1	1	0·4888	200	100	30	0·0025	0·0006
10	5	1	1	0·4888	100	50	15	0·0090	0·0023
10	5	2	1	0·4888	400	300	25	0·0010	0·0003
10	5	3	1	0·4888	400	300	25	0·0010	0·0003
10	5	4	1	0·4888	400	300	30	0·0009	0·0002
10	5	5	1	0·4888	400	300	30	0·0007	0·0002
10	5	10	1	0·4888	400	300	30	0·0018	0·0005

In the indication of these and previous experiments we found warrant for the prosecution of the quantitative tests of the following series:

Weighed portions of a standard solution of potassium chloride (whose value was determined by precipitating with silver nitrate with the usual precautions, collecting in a perforated crucible upon asbestos felt the silver chloride found, and drying and weighing it) were transferred to Erlenmeyer flasks of 500 cm³ capacity, water was added with 10 cm³ of sulphuric acid [1 : 1], 2 grm. of ferric sulphate (either in the form of iron alum or an equivalent amount of ferrous sulphate oxidized in concentrated solution with a sufficiency (0·3 cm³) of nitric acid) and 1 grm. of potassium iodide, were introduced, the whole volume was brought to 400 cm³, and the liquid was boiled with the addition of nitric acid as indicated in the table, 1 cm³ being added after it appeared that all iodine had been expelled.

The color of the ferric salt renders it impossible to tell by the appearance of the solution the exact moment when the iodine has been expelled, and starch paper loses its sensitiveness in hot vapors. We bestowed some attention, therefore, upon means for the detection of small amounts of iodine in

hot steam in order to avoid the inconvenience of condensing the distillate and testing it for iodine. We found that red litmus, preferably wet, is a most sensitive agent for the detection of iodine under the circumstances, taking on with exposure to traces of the vapor carrying that element, a distinct gray blue, deepening with exposure to larger amounts into a lavender blue. The addition of 0·005 grm. of iodine to 400 cm³ of boiling water produces immediately upon red litmus paper the characteristic lavender blue color, and the test grows fainter and fainter as fresh test-papers are exposed, until at the end of five minutes, or thereabouts, when the litmus paper shows no color, the cooled solution yields no iodine to nitrous acid and chloroform. This reaction of litmus we found of great value and in no case in which an exposure of two minutes' duration failed to develop the characteristic color were we able to find iodine in the cooled liquid. To prevent mechanical loss of liquid we made use of the trap described in a previous paper from this laboratory, consisting simply of an ordinary two-bulb straight drying tube cut off short and hung with the large end downward in the mouth of the Erlenmeyer flask. The residue in the flask after the expulsion of the iodine was treated with silver nitrate, and the precipitated chloride was determined similarly to that obtained in standardizing the solution of potassium chloride.

Several determinations in blank—that is, experiments from which the iodine was purposely omitted—are included, for the sake of comparison, in the tabular statement.

SERIES I.

H_2SO_4 [1 : 1].	$Fe_2(SO_4)_3$.	HNO_3.	KCl=HCl.		KI.	Initial volume.	Final volume.	Time in Minutes.	AgCl=HCl. found.		Error.
cm³.	grm.	cm³.	grm.	grm.	grm.	cm³.	cm³.		grm.	grm.	grm.
10	2*	--	0·4960	0·2425	--	400	300	40	0·9536	0·2425	0·0000
10	2*	--	0·4970	0·2429	--	400	300	40	0·9534	0·2624	0·0005—
10	2*	--	0·4942	0·2416	--	400	300	30	0·9509	0·2418	0·0002+
10	2*	2	0·4969	0·2429	--	400	300	30	0·9559	0·2431	0·0002+
10	2*	3	0·4956	0·2423	1	400	350	30	0·9546	0·2428	0·0005+
10	2*	3	0·4969	0·2429	1	400	350	23	0·9662	0·2432	0·0003+
10	2†	3	0·4949	0·2419	1	400	300	27	0·9523	0·2422	0·0003+
10	2†	5	0·4970	0·2429	1	400	250	55	0·9559	0·2431	0·0002+
10	2†	5	0·4955	0·2422	1	400	300	30	0·9524	0·2422	0·0000
10	2†	5	0·4967	0·2428	1	400	300	33	0·9546	0·7428	0·0000
10	2†	6	0·4964	0·2427	1	400	300	30	0·9550	0·2429	0·0002+

These eminently satisfactory results prove the trustworthiness of the method.

* The iron was added in the form of iron alum.
† The iron was added as $FeSO_4$ oxidized by HNO_3.

The fact that nitric acid appears to affect so little the hydrochloric acid in the solution, suggested the possibility that nitrous acid itself might be turned to account and used in a similar process instead of a ferric salt and nitric acid. Some preliminary experiments were made, therefore, to test the behavior of hydrochloric acid under the action of nitrous acid, and, as they gave favorable indications, the experiments of Series J were undertaken to test the action quantitatively. The general conduct of the test was similar to that followed in Series I. The solution of chloride and iodide containing 10 cm³ of sulphuric acid [1:1] was diluted to 400 cm³, and agitated while the gas developed by the action of sulphuric acid on 2 grm. of sodium nitrite was passed into it. With pure sodium nitrite at hand there is probably no serious objection to introducing that substance directly into the solution, but impurities in the article at our disposal made it desirable to generate the gas outside the solution.

For a generator we used two straight drying tubes connected by a rubber tube and set up after the fashion of the von Babo generator, and regulated the rapidity of the current to a rate of five or six bubbles to the second by changing the relative elevation of the generator tubes. The iodine separates immediately upon the introduction of the nitrous fumes and escapes upon boiling in dense fumes, leaving the solution colorless in a very short time. The litmus test was applied as an additional safeguard to indicate the completion of the removal of the iodine. The results of the experiments as given in the accompanying table are evidently satisfactory.

SERIES J.

H_2SO_4 [1 : 1].	$NaNO_2$ used in generator.	KCl=HCl.		KI.	Initial volume.	Final volume.	Time in minutes.	AgCl found.	HCl. found.	Error.
cm³.	grm.	grm.	grm.	grm.	cm³.	cm³.		grm.	grm.	grm.
10	2	0·4953	0·2421	1	400	350	20	0·9524	0·2422	0·0001 +
10	2	0·4975	0·2432	1	400	350	16	0·9573	0·2434	0·0002 +
10	2	0·4956	0·2423	1	300	250	15	0·9530	0·2423	0·0000
10	2	0·4973	0·2431	1	300	250	15	0·9550	0·2429	0·0002 —
10	2	0·4964	0·2427	1	300	250	15	0·9550	0·2429	0·0002 +
10	2	0·4969	0·2429	1	300	250	15	0·9567	0·2433	0·0004 +

The modes of proceeding to the separation of iodine and the estimation of chlorine according to the processes which we have detailed may be briefly summarized as follows:

First Method.—To the solution of the alkaline chloride and iodide diluted to about 400 cm³ in an Erlenmeyer flask capable of containing a liter, are added 10 cm³ of sulphuric acid of

half strength, with 2 grm. of ferric sulphate (either in the form of iron alum, or ferrous sulphate oxidized in concentrated solution by about 0·3 cm^3 of nitric acid), and 3 cm^3 of nitric acid. A trap, of the form described, is hung in the neck of the flask, and the liquid is boiled until the steam which escapes no longer gives to red litmus paper, after two minutes' exposure, the characteristic gray blue due to traces of iodine. Then 1 cm^3 more of nitric acid is added, and the test for iodine again made. When no iodine is found in the escaping vapor, silver nitrate is added in excess to the contents of the flask, the precipitate is settled, collected in a perforated crucible on asbestos, dried, and weighed as silver chloride.

Second Method.—The solution of the chloride and iodide contained in an Erlenmeyer flask is diluted to 400 cm^3; 10 cm^3 of sulphuric acid of half strength are added, and the vapor from 2 grm. of sodium nitrite acted upon by dilute sulphuric acid (preferably in a simple generator, such as is described above) is passed with reasonable rapidity into the agitated solution. The liquid is boiled until colorless, and still further until litmus paper placed in the steam gives no reaction for iodine after an exposure of two minutes. The contents of the flask are treated with silver nitrate, and the precipitated chloride is treated exactly as in the first method.

Both methods are convenient and precise.

ART. XXXVIII.—*On the occurrence of Polycrase, or of an allied species, in both North and South Carolina;* by W. E. HIDDEN and J. B. MACKINTOSH.

A FEW crystals of the mineral here described were brought to the attention of one of us while prospecting in the summer of 1888 for ores of thoria in the zircon region of Henderson County, North Carolina. The new thorium-phosphate (Auerlite)* had lately been discovered in that neighborhood and this yttrium-uranium mineral was considered by its finders to be identical with it. Its yellow exterior alteration bore a great resemblance to auerlite, particularly to that variety found on the Price land, but its form, density, dark interior color, and bright resinous fracture suggested a closer relation to euxenite, polycrase or samarskite. The locality was visited and the work of developing it promptly commenced.

In an announcement of a new occurrence of xenotime-cyrtolite, printed in this Journal (Nov., 1888), the first notice of this

* This Journal, Dec., 1888.

locality is given and the mineral here described is therein referred to as "a member, as yet unidentified, of the samarskite group." No analysis was then attempted, as the material on hand was impure, and insufficient; we hoped for purer and larger masses as the locality became developed. Up to July, 1889, the character of the mineral was not fully determined, and a very considerable amount of labor had been fruitlessly expended in an endeavor to find it and xenotime in commercial quantities. Altogether only about 100 grams had been found, the work being carried on after the manner of placer gold-washing. The locality is on the Davis land, in Henderson Co., North Carolina, at a place on the "old Greenville Road" where it is crossed by a decomposing and low lying granitic formation. It is about four miles from Zirconia (a railroad station), and not far from the South Carolina state line. The associated minerals are zircon, monazite, xenotime, cyrtolite and magnetite. Of the first four of these about one ounce would be found, in the concentrates, upon washing about one cubic yard of the kaolinized granite.

This mineral is invariably found in separate crystals, no massive variety being as yet observed, and they have a type of form greatly resembling figure 434, of polycrase, in Dana's System of Mineralogy. They are always more or less altered on the surface to a pale yellow gummite-like substance, and the line of demarcation from the unaltered to the altered mineral is very sharply defined, no intermediate stages of alteration being evidenced.

No satisfactory measurements of angles were possible. The crystals were small, thin, square flattened prisms, with several terminal planes (in one zone only). One brachydome had an angle of about 133½° on the brachypinacoid. One twin, parallel to the unit brachydome, was observed quite perfectly developed.

The pure mineral is nearly coal-black, with a brownish yellow translucence through thin edges. Its fracture is small conchoidal with a brilliant sub-metallic to resinous luster. No cleavage was noticed. The density as taken on a gram of carefully selected grains of the broken dark internal cores was found to be 4·78. Another determination on a single mass gave 4·724. Its hardness = 5·5. Streak and powder light yellowish brown, approaching to white. When heated it decrepitates slightly and becomes dark brown. It is infusible.

The material analysed was the same as that upon which the higher density was determined and the results were as follows:

			Oxygen ratio.	
Cb_2O_5 ----------	48·97	28·52*	?	?
Ta_2O_5 ----------		-----		
TiO_2 ----------		20·27†		
Y_2O_3, etc. ----------	27·55	At. w't. = 103·8	32·37	52·71
Fe_2O_3 ----------	3·19	----------	6·00	
UO_2 ----------	13·77	----------	14·34	
H_2O (lgn.) ----------	5·18	----------		28·83
	98·48 %			

The analysis was conducted in general after the method of J. Lawrence Smith, using hydrofluoric acid. The mineral is completely soluble in boiling sulphuric acid when very finely powdered.

An H_2SO_4 solution of both these minerals show, when HCl and metallic zinc are added, at first a faint violet color then momentarily a deep sapphire-blue which changes to greenish and finally to a deep brown. The solution then clears and a muddy precipitate forms. The reactions are quite similar to the behavior of the Hitteroe polycrase.

The foregoing statements comprised our data of this mineral up to the discovery, in September last, of another occurrence of the same species on a more satisfactory scale. Whereas we had formerly a few grams we now have ounces, and where before we had small pieces of impure material we now have large crystals of almost normal purity. The alteration-products are also now available for separate examination, and our present supply of crystals includes many that weigh from 5 to 10 grams each and one of one ounce. All have the same habit as those first described. Some, as before stated, are quite pure, while others are almost wholly changed into a lemon-yellow *gummite* which has Sp. Gr.=3·33+. Hardness=3·5. Loses 11·46 per cent after ignition and becomes dull-brown. When opportunity offers we intend looking into it more thoroughly. Minute radiated tufts of what may prove to be tengerite were also noticed in the clefts of the mineral.

The new material unfortunately does not offer smooth enough surfaces for exact measurement of angles. The crystals present the macro- and brachypinacoids as predominating planes, with the brachypinacoid usually the larger. One brachyprism (i-$\breve{3}$); two brachydomes (1-$\breve{i}$, 2-$\breve{i}$); one brachydiagonal pyramid (1-$\breve{3}$); and one macrodome ($\frac{1}{3}$-$\breve{i}$), which latter is new to the species. Several specimens of a twinning parallel to the new macrodome were observed; this is peculiar for the reason that at the first locality the only twin observed was parallel to

* This gave the blue reduction test with zinc.
† This gave the violet test by reduction with zinc.

the unit brachydome. As the angles were obtained by a hand goniometer and are only approximate they are not considered worthy of record.

With this mineral (of which ten kilos have thus far been mined), we have found only a few small pieces of allanite (Sp. Gr. = 3·54), and one small mass of uraninite (?), having gummite and uranotil as a coating, its density was 7·22, both species of which are not found at the North Carolina locality. The exact situation of the new deposit is, just at this writing, unknown to us, but it is near the "Upper Saluda River," just over into South Carolina, and is distant about twenty miles from the first described locality.

The density of the new crystals varies between 4·925 and 5·038.

The pure mineral was first pulverized and then rubbed very fine, with alcohol, in an agate mortar. It then went into perfect solution when boiled with sulphuric acid. Excepting that it does not decrepitate before the blowpipe it is otherwise very much like the North Carolina mineral. It is slightly harder (6) and its streak and powder are pale snuff-brown, and darker than the North Carolina mineral.

The analysis is as follows:—

			Oxygen ratio.	
Cb_2O_5	47·88	14·30	?	?
Ta_2O_5		----		
TiO_2		33·58		
Y_2O_3, etc.	21·23	At. w't. = 114·1	23·06	48·58
PbO	0·46		0·20	
FeO	2·47		3·43	
Fe_2O_3	0·18		0·33	
UO_3	19·47		20·35	
CaO	0·68		1·21	
H_2O (Ign.)	4·46			24·78
Insoluble	0·12			
SiO_2	1·01			
	97·96			

Both of the analyses show a loss for which we cannot account, though the presence of fluorine was unmistakably detected in the South Carolina mineral. Thoria is absent in both cases.

Our attempts at separation of the metallic acids, contained in both the minerals, were very unsatisfactory. In fact the method by fusion with sodium bisulphate, even when repeated several times, did not give reliable results under our treatment. Until we have separated the metallic acids present, entirely to our satisfaction, we do not propose to offer any conjectural formulæ for these analyses. We will state though that this

mineral seems to be very closely allied to, if not identical with, the polycrase from Hitteroe, Norway, analyzed by Rammelsberg; in which he found

Cb_2O_5	20·35
Ta_2O_5	4·00
TiO_2	26·59
Y_2O_3	23·32
Er_2O_3	7·53
Ce_2O_3	2·61
FeO	2·72
UO_2	7·70
H_2O	4·02
	98·84

By calculating the above, without knowing the molecular weight of the Y_2O_3 group but taking it to be 89·5, we arrive at the following approximate formula:

$$Cb_2O_5,\ 4TiO_2,\ 5RO,\ 2\tfrac{1}{2}H_2O,$$
$$\text{or } 2Cb_2O_5,\ 8TiO_2,\ 10RO,\ 5H_2O,$$

which may also represent our mineral when the metallic acids have been accurately separated and their individual molecular weights definitely ascertained; this we propose to do as opportunity offers. In conclusion we call attention to the fact that this is the first occurrence of a columbo-titanate accredited to an American locality.

ART. XXXIX.—*Origin of some Topographic Features of Central Texas;** by RALPH S. TARR.

THE Central Paleozoic area of Texas is a region of older rocks exposed by the removal of the overlying unconformable Cretaceous. The southern portion of this area has since the very earliest times been the seat of extensive denudation as long as any land area remained above the sea. The Potsdam sandstone perhaps derived its sediment from the still older metamorphic rocks. A conglomerate layer in the Lower Carboniferous series contains pebbles from the Silurian rocks. The same is true of the conglomerate in the Upper Carboniferous; and the Trinity beds, the lowest of the Cretaceous system, when conglomeritic, contain, in this region, chiefly Silurian pebbles. The Quaternary drift has the same peculiarity.

* Published by permission of Mr. E. T. Dumble, State Geologist for Texas.

Briefly outlined, geological history, commencing as far back as I have studied it, begins with an old pre-Sub-carboniferous land of Silurian and older rocks. At present this system appears as a patch of very much metamorphosed rock surrounded on three sides by Cretaceous. Little is known of this region. It is plainly a very much degraded mountainous land-area which has furnished thousands of feet of strata for the later formations. As to its former boundaries little can be said; but I have given elsewhere* what I believe to be evidence of a former northward extension. The tract contains marble, sandstones and schists of Lower Silurian and earlier age; but the Upper Silurian and Devonian if they exist at all are mere remnants. The stratigraphy is greatly complicated by faults and folds.

In Lower Carboniferous time a submergence and long continued period of sedimentation permitted the deposition of an extensive series of Lower Carboniferous limestone, several thousand feet of which are still exposed between the Silurian on the south and the overlapping Upper Carboniferous to the north. The old shore line of the Lower Carboniferous sea may be plainly traced in favorable places, and here, particularly in the upper beds, may be seen the varied shore deposits of that time.

A gap of unknown value, accompanied by a tilting and slight crumpling of the Lower Carboniferous limestone series intervened between the close of that period and the beginning of the Upper Carboniferous. The latter beds rest unconformably upon the lower limestone. This series fully 8,000 feet thick consists of the usual alternation of beds so typical of that period.† The upper beds indicate an approach to the Permian condition of an inland sea. What intervened between the Permian and Lower Cretaceous has not yet been made out. That a portion of the Carboniferous had a dry land condition for at least a part of the time is proved by the irregularity of the contour beneath the Cretaceous. It is impossible to say to what extent this land condition was shared by the surrounding areas; but the Carboniferous of the Colorado river valley and the neighboring Silurian shows signs of erosion by the position of the lowest bed of the Cretaceous, the Trinity sands of Hill. The Trinity sands rest on the Carboniferous on the east as low as 1250 feet above the present sea level; but in the western portion they are on the 2000 foot contour line. There is a rise of 750 feet in less than fifty miles. A carefully made map of these beds may reveal to us an interesting history of the immediate pre-Cretaceous land. The Silurian area was

* The American Geologist, forthcoming number.

† See 1st Annual Report Texas Geol. Survey.

then more elevated than the Carboniferous and the rise in the land was from east to west.

The extensive sedimentation of the Cretaceous time completely obliterated all pre-existing topography. The deep sea conditions and accompanying thick deposits, so plainly proved by Prof. R. T. Hill, covered all land with a thick mantle. When this deposit was finally raised above the sea and a new era of erosion began, the large streams which first established themselves commenced to flow without regard to the topographic and geologic features buried beneath the Cretaceous. The Tertiary beds which occupy a large portion of east Texas mark the extension of the oceanic waters many miles farther than at present. It is probable that the Tertiary ocean extended much farther inland than at present indicated and that the beds have been in part removed by later erosion. It is plain from this that the waters of the new drainage systems emptied into an ocean not far removed from the buried Paleozoic area. What were the conditions west of the Paleozoic has not been ascertained. One stream, the ancestor of the present Colorado, established itself in the Southern Carboniferous area, and another, the Brazos, crosses this system farther north. These streams with their tributaries have eroded the Cretaceous from much of the Carboniferous, and the Colorado has in addition removed the Cretaceous from a great area of Silurian.

The history of these operations is not thoroughly plain in every point. The extensive denudation in this Paleozoic area must mean that this was early a region of strong erosion, and that this condition has been continued. It may also mean that this was the highest region of the new land. Be this as it may the fact remains that in this area, by means of two large rivers and several well established tributaries, a great thickness of Cretaceous has been eroded away and some of the Paleozoic removed. This process has established a series of interesting topographic features, some of which throw light upon the later history of the drainage systems.

The Colorado, which rises in the Staked Plains, while well established in its lower and middle course is rapidly extending its drainage area by headwater erosion in the plains. Deep cañons and arroyas mark its new work in this region. Over the Paleozoic it flows with rapid fall and a wonderfully serpentine course without regard to structural features. That it is a superimposed stream is proved by the fact that it is now busy eroding barriers of Silurian and other hard rocks which it has unexpectedly reached after passing through the Cretaceous strata. The larger tributaries flow equally without regard to structural features; but the smaller tributaries of more recent

origin have cut valleys in places of structural weakness. This is well shown in the case of the Waldrip coal beds, a series of easily eroded strata, which, for a distance of forty miles, are marked by the presence of small streams and valleys. Similar instances are numerous.

In the erosion, accomplished under such complicated circumstances of accident and geological peculiarity a series of distinct topographic outlines has been evolved. The Silurian, a region of hard rocks, complicated by innumerable folds and probably also retaining a well defined topographic outline evolved in pre-Cretaceous times, is now a hilly country. A portion of the Lower Carboniferous is involved in this region of strong relief but practically the border of the Silurian marks the beginning of the highlands. Once partially rid of its Cretaceous cover, this area would necessarily become a region of strong erosion and this explains the almost complete removal of the Cretaceous from that surface.

The Carboniferous on the other hand is a region of soft rock and gentle dip, and this becomes rapidly degraded. The Carboniferous surface, as shown by the position of the Lower Cretaceous upon it, was when the present drainage systems reached it, considerably below the Silurian; and using this same datum plane, it is evident that very little of the Carboniferous has been since removed. One chief reason for this is that on reaching the Paleozoic the down-cutting of the Colorado has been indefinitely delayed by the hard Silurian and other rocks which it is now engaged in removing. The San Saba river, for instance, for a distance of fifteen miles above its mouth, flows in a flood plain because of the impossibility of eroding deeper until after the Colorado has removed the barriers below. The small streams tributary to the San Saba are similarly affected, and the same is true of other tributaries of the Colorado, as for instance the Pecan Bayou. The chief erosion that is being done in the Carboniferous of the Colorado river is in the headwaters of the small streams, and the material thus removed is deposited lower down in flood plains to be removed when erosion at that point can proceed. A local base-levelling is thus in process relative to the dammed-back Colorado. This process is aided by the peculiarity of rainfall. During the greater part of the year the small creeks either contain no water at all or so little that no work of erosion is done. During some months tumultuous torrents rush down the stream valleys covering the previously dry bed with water twenty feet deep and thirty feet wide. These torrents subside very quickly, but during their brief existence do an immense work of erosion. The Colorado river has a wide channel for ordinary periods of flow; but the high-water channel is two or

three times as wide. A terrace twenty-five or thirty feet above the river bed, sometimes on one side sometimes on both, has been cut by the high water. The river sometimes rises forty or even fifty feet, as is strikingly shown by the presence of rafted logs near the top of Pecan trees. Great as are the floods at such time they are incapable of carrying off all the sediment and the flood plains are rapidly growing, at least in the area affected by the dams in the older Paleozoic region. Upright tree trunks, comparatively fresh, are sometimes exposed for a distance of five feet above the roots, and bones of the mastodon are found both in the alluvial deposits of the Colorado and its tributaries.

That there has been a period of very rapid erosion just previous to the present condition is attested to by numerous points of evidence. The Colorado is flowing in a somewhat degraded cañon above the Silurian; and where the rocks are hard enough to resist rapid erosion this cañon character is well preserved. The butte type of erosion so typical of the bordering Cretaceous is also, I believe, an evidence of previous rapid erosion. One example, the Santa Anna Mts. (so called), remains in the center of the Carboniferous. There are two buttes, side by side and divided by headwater erosion, in Coleman county, fully fifteen miles from the nearest notch of Cretaceous. The capping stratum is a compact magnesian limestone, the lowest of the Caprina division of Hill. The lower beds are Trinity sands. The length along the top is a little more than a mile, the height 250 feet. Five distinct large creeks head in the region near these buttes, which are the last remnant of a Cretaceous divide. The hard stratum on the top which permits the retention of the butte outline is one of the several strata which in the bordering Cretaceous gives the topography its benched mesa and butte outline, a topography so characteristic that a person can with safety predict Cretaceous as far as he can see the outline.

The degraded cañon character of the Colorado valley and the sharp benched and butte outline of the Cretaceous seem to indicate a period of hurried erosion of recent date; and the early Quaternary uplift which placed the Tertiary above the sea may very well be correlated with this period.

From this it would seem that the middle Colorado originally starting on the new Cretaceous land is now superimposed upon the older Paleozoic, with which it is engaged in a struggle brought about more quickly by its rejuvenation by elevation. Owing to the vicissitudes then imposed, it is tending to reach a temporary old age in the portion above the barriers and this tendency is being increased by the peculiarities of rainfall.

The combination of geological structure and peculiarity of erosion has given rise to three types of topographic outline. 1st, the rugged hilly topography of the plicated and metamorphosed Silurian rocks, an outline in part descended from an existing pre-Cretaceous topography. 2d, a low hilly Carboniferous area with many broad-topped hills, especially where the Cretaceous has just been removed. On account of the destructibility, this area is being rapidly degraded and the cañon character of the Colorado is therefore rapidly disappearing, thus destroying the evidence of the recent rejuvenation. 3d, the sharp angular outline of the butte and mesa type in the Cretaceous area which is rendered possible by the nearly horizontal nature of the beds and the alternation of hard and soft strata, but which has probably been aided also by the rapid erosion which followed the early Quaternary uplift.

Art. XL.—*On the Formation of Silver Silicate;* by J. Dawson Hawkins.

But very little seems to have been done with regard to the formation of silicate of silver in the wet way. In Gmelin-Kraut's Inorganic Chemistry, vol. iii, p. 970, the following statement is made:—"A solution of Ag_2O in $2(HF)SiF_4$ evaporated to the consistency of a syrup, deposits hydroscopic crystals of $2AgF . SiF_4+4H_2O$. Out of a solution of this compound, ammonia precipitates a yellow basic salt, if added in small quantities. An excess of ammonia precipitates silicate of silver." A like statement is made by Berzelius—Lehrb. d. Chemie; Dresden, 1836, vol. iv, p. 629. With the exception of a paper by Dr. M. W. Iles,* nothing seems to have been done in this direction since then. With regard to the production of silver silicate in the wet way, Dr. Iles merely repeated the above experiment, without making any analysis of the precipitate.

The method I have used is so simple that it seems strange that it has not been used before. The reaction made use of was:

$$Na_2SiO_3+2AgNO_3=Ag_2SiO_3+2NaNO_3.$$

The solution of Na_2SiO_3 was made by fusing together Na_2CO_3 and SiO_2, and dissolving the mass in water. The amount of SiO_2

* Engineering and Mining Journal, April 19, 1884.

used was slightly in excess of the molecular proportion, and the silicate formed was therefore slightly acid. This solution was added to a neutral solution of $AgNO_3$, and a lemon-yellow precipitate was thrown down. This was washed carefully with hot water, and dried. Dried between filter paper, the salt retains its original yellow color, but when completely dried in a bath, the color becomes darker. Two analyses gave the following results:

Ag_2O	77·42	77·41
SiO_2	22·66	22·52
	100·08	99·93

Ag_2SiO_3 requires Ag_2O 79·45, SiO_2 20·55. This salt is, then, slightly acid, which agrees with the conditions of the precipitation, as the meta-silicate of sodium was slightly acid. From this it appears that all that is necessary to prepare a silicate of silver of a certain composition, is the pure corresponding sodium salt, and a neutral silver solution.

The silicate of silver is readily decomposed by all acids, and is perfectly soluble in ammonia. It bears a considerable degree of heat without decomposition, first changing its color to brown red, then back to the original yellow, a red heat, however, resolves it into Ag, O, and SiO_2.

The above is intended merely as a preliminary notice, as I am still engaged in a further study of the salt and will publish my results when they are complete.

Laboratory of the Globe Smelting and Refining Co., Denver, Colorado.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Determination of Vapor Density below the Boiling Point.*—Demuth and V. Meyer have modified the Meyer vapor density method so as to allow the determination to be effected at temperatures below the boiling point of the substance employed. In Hofmann's method this object is attained in consequence of the diminished pressure, as is well known. The author conceived that the same result might be reached by filling the bulb of the Meyer apparatus with hydrogen, a gas lighter than air and also of greater diffusibility. The apparatus used is essentially the same. The material whose vapor-density is to be determined, if

solid, is introduced into the bulb, previously filled with hydrogen, in the form of small cast sticks. If liquid, it is placed in small tubes of Wood's fusible metal when the temperature to be employed is above 60° to 80°, the fusing point of the metal, or in tubes of glass, stoppered, when the temperature is below this; the stopper being shaken out by tapping with the finger. The bulb should have a capacity of about 100^{cc}, and a diameter of three centimeters; and the bottom which must not be too thin, is somewhat flattened to facilitate the volatilization of the substance. The neck is to have a diameter of not over 4 or 5 millimeters; and the quantity of the substance taken should be such as to produce an expulsion of 9 to 11^{cc} of gas from the vessel. It is not desirable with this method of working to cover the bottom with sand or asbestos, since these substances retard the production of vapor; but the bulb may be protected by a small spiral of platinum wire, or some mercury may be placed in it. Results are given, in the paper, of the determination of the vapor-density of xylene at 100°, (40° below its boiling point), of nitrobenzene 23° and 30° below, of naphthalene 35° below and of para-nitrotoluene 33° below the boiling point. Also of ethyl ether at the ordinary temperature of the laboratory, 17°, its boiling point being 35°. These results show the method to give satisfactory results.—*Ber. Berl. Chem. Ges.*, xxiii, 311, Feb., 1890. G. F. B.

2. *On the Vapor-density of Aluminum Chloride.*—In consequence of the results obtained by Friedel and Crafts,* Nilson and Pettersson have repeated and extended their experiments on the vapor-density of aluminum chloride. In meeting the criticism of the French chemists upon their method, they observe that for every volatile substance, there exists a certain range of temperature within which the vapor-density is a function not only of the temperature but also of the pressure. Within this interval, which they call a region of gas-dissociation, they concede that the method of Dumas gives the true vapor-density, that of Meyer (or of Dulong, as they call it) giving values which are always too low. But as soon as the temperature is reached at which the density of the vapor becomes constant, the same results are obtained whichever of the two methods be employed. Since the law of Avogadro is true only for bodies in the condition of true gases, and since in the state of a perfect gas the density is independent of the temperature and the pressure, and the two methods then give identical results, it would seem that Friedel and Crafts were hardly justified in giving the preference to one of these methods, rather than to the other. Accordingly the authors undertook a re-determination of the vapor-density of aluminum chloride, employing both methods for the purpose. For the Meyer method they employed a protecting tube of Bayeux porcelain placed in a Perrot furnace for the higher and a tube of Thuringian glass for the lower temperatures. The density obtained, referred to air as

* This Journal, xxxvi, 465, Dec., 1888.

unity, was, in the vapor of sulphur at 440° 7·30, 7·50 and 7·40; in that of phosphoric sulphide at 518°, 7·16 and 7·20; in that of stannous chloride at 606°, 6·34; in the furnace at 758° 4·80; at 835°, 4·54; at 943°, 4·56; at 1117°, 4·27; at 1244°, 4·25; at 1260°, 4·28; about 1400°, 4·26; about 1600°, 4·08. It appears from these results that between 440° and 758° the vapor of aluminum chloride is in a condition of permanent dissociation and that it does not attain a normal gaseous condition until the temperature reaches 800°, when the vapor-density becomes 4·60 and the molecular mass 133·15 corresponding to the formula $AlCl_3$. Between 800° and 1000° there can be no doubt that aluminum chloride has a constant density agreeing with the composition $AlCl_3$. For the Dumas method, the aluminum chloride, formed by passing hydrogen chloride gas over the metal, was sublimed directly into the cylindrical bulb, of about 100^{cc} capacity. After heating so long as vapor was evolved the tube was sealed, cooled and weighed. It was then opened under mercury and the volume of residual gas measured. After washing and drying the tube it was again weighed, the difference being the apparent mass of the aluminum chloride and of the residual gas. It was then filled with dry air, sealed and weighed a third time. The difference between the second and third weighing gave the apparent mass of the air. It was then filled with water and weighed for the purpose of calculating its capacity. The vapors employed for heating were those of nitrobenzene, 209°, engenol, 250°, diphenylamine, 301°, mercury, 357°, antimonous iodide, 401°, and sulphur, 440°. The vapor-densities obtained varied from 9·92 at the lowest temperature to 8·78 at the highest; being 9·62, 9·55, 9·34, and 9·02 at the intermediate ones. These results, therefore, confirm those obtained by Friedel and Crafts as to the general fact that there is a vapor-density of 9·20 within these limits of temperature. But this value is not constant and happens to exist at about the boiling point of mercury; while within a range of 50° above and below this point it varies considerably, and between 209° and 440° it changes by an entire unit. The authors conclude, therefore, (1) that starting from the boiling point, aluminum chloride is continually dissociated as the temperature rises, not becoming a perfect gas until 800° is reached; at which point the vapor-density 4·55 is attained corresponding to the formula $AlCl_3$ and the molecular mass 133·15; (2) that this vapor-density is departed from only very slightly even at the highest temperatures attainable; and (3) that hence aluminum is trivalent.

In the following paper Friedel regards the conclusions of Nilson and Pettersson as too absolute. If there is dissociation between 200° and 400° there must exist a vapor capable of dissociating, and this can be only Al_2Cl_6. Moreover, if curves be constructed representing the results given by the two methods, these curves do not unite with each other to form a single curve. The determination of density between 200° and 400° is regular, as is also that above 600°; while the portion

between 440° and 600° appears to have a point of inflexion corresponding to a maximum dissociation. He thinks the most natural conclusion to be that like amylene bromhydrate, aluminum chloride has two vapor-densities; one between 200° and 400° corresponding to the formula Al_2Cl_6, and a second above 800°, corresponding to the formula $AlCl_3$.—*Ann. Chim. Phys.*, VI, xix, 145, 171, February, 1890. G. F. B.

3. *On the Combination of Potassium and Sodium with Ammonia.*—JOANNIS has observed that when an equivalent mass of alkali-metal is dissolved in twenty times the equivalent mass of liquefied ammonia, and the ammonia is gradually removed, the pressure falls very rapidly, becoming after a certain time constant and equal to 170^{mm} at 0°. The residue has the composition $Na+5{\cdot}3\ NH_3$; but since the proportion of ammonia varies with the temperature, it is probably not a definite compound. As more ammonia is removed, a dark red solid substance, darker even than copper, is deposited from the red solution, the pressure remaining constant. Finally, when one equivalent mass of ammonia to one of metal remains, the liquid has completely disappeared and there is left only solid sodium-ammonium or potassium-ammonium. On reducing the amount of ammonia still further, the free alkali-metal gradually separates, the pressure remaining uniform; a dissociation therefore taking place, the pressure of which is equal to that of the saturated solution.—*C. R.*, cix, 900, Dec., 1889. G. F. B.

4. *On the Preparation of Platinic fluoride.*—MOISSAN has succeeded in preparing anhydrous platinic fluoride by passing a current of fluorine over a bundle of platinum wires contained in a tube of platinum or fluor spar, heated to 500° or 600°, and condensing the product in a dry glass vessel. The fluoride forms a dark-red mass either fused or made up of chamois-colored crystals. It is very hygroscopic and yields a yellow solution with water, which almost instantly decomposes with evolution of heat, yielding platinic hydroxide and hydrogen fluoride. It is thus made evident why platinic fluoride has not been obtained in the wet way. On heating to redness platinic fluoride decomposes readily, yielding pure fluorine and crystallized platinum; thus furnishing the best method of obtaining fluorine pure. Gold treated in a similar way yields a similar fluoride.—*C. R.*, cix, 807, Nov., 1889. G. F. B.

5. *On Xylose or Wood-sugar, a new Penta-glycose.*—WHEELER and TOLLENS have examined the sugar discovered by Koch in wood and called xylose. It was prepared by the hydrolysis of wood-gum, obtained from beech wood. The saw dust from this wood, after extraction with ammonia was digested with a five per cent soda solution for 48 hours and precipitated with 95 per cent alcohol. After washing with acidulated alcohol, the precipitate was treated with ether, and the residue, dried over sulphuric acid, left a porous mass almost colorless. To prepare the xylose 50 grams of this gum were boiled with

400^{cc} water and 20 grams of concentrated sulphuric acid in a flask connected with a vertical cooler. After 11 or 12 hours boiling, the solution was saturated with calcium carbonate, filtered and evaporated to a syrup, then dissolved in strong alcohol, again filtered and evaporated, and treated with absolute alcohol. The evaporated syrup from this solidified to a crystalline mass after a few days. Repeated recrystallization and a treatment with animal charcoal gave a pure white crystallized sugar, fusing at 144° to 145° and giving on analysis the formula $C_nH_{2n}O_n$. It is dextrorotatory, $[\alpha]_D = +18°$ or 19° for a solution which had been made some hours. But it shows the so-called bi-rotation markedly, the rotation five minutes after solution being $[\alpha]_D = +85{\cdot}86°$ or four and a half times that of a solution after 16 hours. From the curve of change it appears that the bi-rotation at the instant of solution must be +100°. In its reactions xylose resembles arabinose; both yield with mineral acids furfurol and not lævulinic acid, as do the carbohydrates; and on oxidation, no mucic nor saccharic acid is formed. Treated with phloroglucin and hydrochloric acid, both yield a cherry-red color, the phenyl-osazones of both fusing at 160°. By Raoult's method xylose was proved to be a penta-glycose $C_5H_{10}O_5$ an isomer of arabinose. It yields trioxyglutaric acid and tri-oxybutyric acids on oxidation while arabinose yields tri-oxybutyric acid only.—*Liebig's Annalen*, ccliv, 304; *Ber. Berl. Chem. Ges.*, xxiii, 15 (Ref.), Jan., 1890. G. F. B.

6. *On the Identity of Cerebrose with Galactose.*—THIERFELDER has examined the sugar obtained from the brain by Thudichum and called cerebrose. It was prepared by the action of dilute sulphuric acid on cerebrin. Since it reduces Fehling's solution, yields mucic acid when oxidized with nitric acid, and resembles galactose in its melting point, specific rotation, fermentation, and phenyl-hydrazine compound, the author regards it as identical with this sugar.—*J. Chem. Soc.*, lvii, 57; lviii, 121, February, 1890. G. F. B.

7. *Dust in the Atmosphere.*—At a meeting of the Royal Society, January 27, Mr. JOHN AITKIN expressed his belief that "dust condenses moisture before the air is saturated. For the same number of dust particles per cubic centimeter, the atmospheric transparency depends upon the depression of the wet bulb, being large when the depression is large, but becoming small before the depression vanishes. Increase of temperature also reduces transparency when the number of particles remains the same, for increase of temperature means increase of vapor pressure. As a rule, quantity of dust decreases when the wind increases. When calms occur dust accumulates. This increases the radiating power of the air, so that it cools quickly and fog forms. Thus a fog may be regarded as a suspended dew."—*Nature*, Feb. 20, 1890, p. 382. J. T.

8. *The Sun's Heat.*—K. ANGSTRÖM, in his carefully prepared papers, gives the result of his investigations upon the effect par-

ticularly of the absorption of the sun's radiation by carbonic acid in the earth's atmosphere. The results of Langley are commented upon, and compared with the author's results. A formula is found which expresses the results fairly well. If i represents the heat passing through an atmospheric layer of thickness d, then $i = A_1 \rho_1^d + A_2 \rho_2^d$ in which A_1 and ρ_1 represent weak and A_2 and ρ_2 strong carbonic acid absorption. ρ_1 can be taken as the mean value of Langley's coefficient. A very satisfactory agreement is found between the calculated and observed values. To carbonic acid absorption the author attributes the sharp rise in the intensity of radiation with high altitude of sun, which Langley's coefficient does not fully express.—*Ann. der Physik und Chemie*, 1890, No. 2, pp. 267–311. J. T.

9. *Method of rotating mirror.*—A. v. Oettingen believes that a plane mirror before a stationary photographic objective is to be preferred to the method of a rotating concave mirror. The images are sharper and there is greater range in the disposition of the apparatus.—*Centralztg f. Opt. u. Mech.*, 8, 1887. *Beiblätter Ann. der Physik und Chem.*, 1890, No. 1, p. 33. J. T.

10. *Thermo-Electricity.*—Dr. DeCoudres, of Leipzig, has succeeded in detecting a thermo-electric tension between compressed and uncompressed mercury. The compression was produced either hydraulically or by means of its own weight acting through a column of mercury. It was found possible to determine with certainty the direction of the thermo-electric current, and to measure its intensity for given pressures and temperatures.—*Nature*, Feb. 27, 1890. J. T.

11. *Measurement of Electrical resistances.*—At a meeting of the Physical Society of Berlin, Feb. 7, Dr. Feussner spoke of the methods adopted at the Government Physico-Technical Institute for the measurement of electrical resistances. The wires are wound upon metallic cylinders in order to provide for the rapid cooling of the wires as they are warmed by the passage of the current; these are then submerged in petroleum, whose temperature is recorded by a thermometer immersed in the liquid, which is itself kept constantly stirred. German silver wires are unsuitable for standard resistances, since their resistance increases with lapse of time. This tendency was attributed to a gradual crystallization due to the zinc in the alloy. Wires made of an alloy of copper and nickel have been examined. Wires made of this alloy possess a very low temperature coefficient, and were found to be very constant after being heated to 100° C.—*Nature*, Feb. 27, 1890, p. 407. J. T.

II. Geology and Natural History.

1. *Subaerial decay of rocks and Origin of the Red color of certain formations;* by I. C. Russell. Bull. U. S. Geol. Survey, No. 52.—In this paper Mr. Russell treats at length of the amount of decay over the middle and southern parts of the Appalachian border of the United States, dwelling on its extent, its relation to

the kinds of rocks, and its earth-making results. Some of the methods of decay are also considered, especially its dependence on the carbonic and organic acids in the soil and on the moisture and warmth of the climate. The great contrast in depth of decomposition between the northern and southern States is dwelt on; and besides explaining this difference by reference to glacial removal in one region and not in the other, and to difference in climate, he refers to the recent elevation in the former region as having quickened erosion and removal by transportation. The author, moreover, sustains the commonly accepted opinion that subaerial decay is still going on as in the past, with like rate of progress. He also dwells on the prevailing red color of the earth and clays resulting from the decay—*terra rossa*, as a wide-spread deposit is called in Europe. Finally, the red color of red sandstones is attributed to the red iron oxide produced by the decomposition or decay, and not to any subsequent change in the history of the deposits.

The contrast in colors between the northern and southern States is spoken of as "a contrast between a glaciated country and a region in which atmospheric decay has progressed uninterruptedly for ages." Mr. Russell, knowing less of New England than of other parts of the country, does not appreciate, as strongly as Professor Crosby whom he criticizes, the full character of this difference. There is wide decomposition at the north, and its rapid progress in the case of syenites, mica schists, gneisses, granites, and hornblende schists during the past forty years is very strikingly exhibited alongside of many railroad cuts. The fact to be accounted for is that these decompositions over New England, whether in the trap of trap dikes or in metamorphic rocks, produces almost *never* red earth, while at the south red earth predominates. The glacial movements and orographic changes have nothing to do with this. The fact is simply that in New England the result of the iron oxidation attending the decay is limonite, the hydrous yellow-brown iron oxide, and not anhydrous Fe_2O_3. The writer has often tried to discover a reason for the different result at the south; he does not find one in Mr. Russell's excellent paper. The question was brought to the writer's attention long since at the volcanic islands of the Pacific (Samoa among them), where the larger amount of rock decay (as about the East Maui Mountain), produces yellow-brown and reddish brown earths, while dry cinder cones (as in the Maui crater), are often red. The decay of a granitoid gneiss a dozen miles east of New Haven goes on rapidly through the oxidation of the iron of the mica; and it makes the rock brown and comparatively weak to a depth in some places of six inches to a yard, with very little attendant decay of the feldspar. Further, the great blocks thus deeply browned have often a *white* exterior two inches or so deep which had been blanched by surface rain-waters, perhaps with the aid of carbonic or organic acids, and this white crust portion is the granitoid rock with the mica gone,

but *the feldspar still sound.* The decayed rock crumbles to the same kind of sand as that out of which the Triassic quartz-feldspar sandstone (arkose) of the region was made.

With regard to the red color of the Triassic sandstone, respecting which the writer is quoted, but misunderstandingly, the fact has been before him that the sands made by decomposition in the region are not incrusted with *red* oxide of iron (hematite), but with brown (limonite); and, accordingly, the condition under which the color became red has been regarded as a subsequent one, as that attending the wide-spread consolidation of the rock. It is explained thus in his Manual of Geology, on page 764 (edition of 1880): "A region invaded by trap eruptions is often also, as a consequent or concurrent fact, a region of steaming fissures and of hot springs, conveying the heated moisture widely through the strata of the region; and thus the sand-beds of the same Mesozoic formations in the Connecticut valley were generally reddened as well as consolidated—the oxidation of iron, when taking place through the agency of hot waters producing the anhydrous red oxide." Under such conditions any limonite present about the grains of the loose sand-beds would have been made red. The sandstone wall-rock of dikes is often of a light gray color, instead of red, because the iron is put by the heat into a silicate condition. Familiar blowpipe experiments illustrate both effects. A touch of the blowpipe-flame will redden most sandstones not already red, from the olive-colored building-stone of New Brunswick to varieties of the white of Ohio; proving, as the writer has stated (1873, 1880), that many great sandstone formations would redden in the early stages of orographic movements, or from heat supplied in any other way. The firm consolidation of a sandstone is, in general, evidence that the needed heat has been present. J. D. D.

2. *Géologie de l' Ancienne Columbie Bolivarienne, Vénézuela, Nouvelle Grenade et Ecuador*; par HERMANN KARSTEN, 62 pp. 4to, with a colored map, two plates of profiles and sections and six plates of fossils. Berlin, 1886 (R. Friedländer & Sohn).—This valuable memoir, on the geology of a large section of northern South America, commences with remarks on the general features of the country under consideration, and a history of previous investigations from the time of Humboldt, ninety years since. The author began his studies of South America in Venezuela and carried them on during the years 1844–47, 1849–56, and his results were the subject of publications between the years 1849 to 1860 and later. The new volume is a collection of all his reports, together with a review of the work of other geologists in the region. The careful descriptions and the colored geological map, together with the paleontological plates and the observations on the volcanoes of the Andes, makes the work one of special importance. The map covers the part of South America west of the meridian of 58½ west and north of the parallel of 5° south. A large area bounded on the north, west

and south by the Orinoco, and Rio Negro is covered by crystalline rocks, which are partly or wholly Archæan. North, west and south of the area the color on the map is that of the Tertiary and Quaternary over a wide region extending to the base of the mountains. Then follows a belt of Cretaceous, either side of narrow ranges of crystalline rocks, with Jurassic beds only over a small area east of Popayan in the U. S. of Colombia (New Grenada). Beyond these crystalline ranges westward there are Quaternary belts along the Magdalena and Cauca Rivers and over a shore region, with intervening belts of crystalline rocks bordered by Cretaceous. No rocks of the Triassic or Carboniferous series, or of any Paleozoic formations, have been recognized, the reports respecting the occurrence of such rocks being errors. The map and the profiles also illustrate the positions of the volcanic cones and areas. The descriptions of the Cretaceous fossils figured were published by the author in the Amtlicher Bericht der Naturforscher-Versammlung in Wien, 1858.

3. *Fossil Sponges and Plants.*—Sir Wm. Dawson has a paper on some remarkable hexactinellid sponges from Little Metis, near Quebec, of the age of the Chazy, in the Transactions of the Royal Society of Canada, iii, 1889, with figures. The paper has notes on the species by Dr. G. P. Hinde. The same volume contains also a paper by the same author giving descriptions of figures of fossil plants from Mackenzie and Bow rivers. The Mackenzie River plants are from the "Upper Laramie or Fort Union Group," "still held by some paleontologists to be Miocene," equivalent of beds in Greenland, Alaska, etc.

4. *Emanations of carbonic acid, sulphurous and other gases at "Death Gulch," Yellowstone Park.*—Mr. W. H. Weed, of the U. S. Geological Survey, has described in Science, of February 15th, 1889, the "Death Gulch" in the extreme northeastern portion of Yellowstone Park, on Cache Creek, two miles above its confluence with Lamar River, five miles from the mail station of Soda Butte. In an opening bordering on Cache Creek occur evidences of former hot springs in geyser-like deposits, a hot spring cone half washed away, a mound of travertine, and a little tepid sulphurous water at the edge of the stream. Besides, there are copious gaseous emanations rising through the waters of the creek "mainly, no doubt, carbonic acid, although containing some sulphuretted hydrogen." Above these is altered and crystalline travertine, besides a bank of sulphur and gravel cemented by travertine. In a lateral gully, the waters of its small stream, sour with sulphuric acid, flow in a channel cut through beds of dark gray volcanic tufa. The only springs now flowing are oozes of water, forming a creamy white deposit about the vents which is largely an alum (alumina sulphate). The odor of sulphur is strong. The bears and other wild animals of the region are often killed by the gases. Dead bears were found in all stages from skeletons to freshly killed, and with them were remains of an elk, squirrels, rock-hares, etc., and many dead butterflies and other insects.

5. *Diatom beds and bogs of the Yellowstone National Park.*—Mr. W. H. Weed, in a paper in the Botanical Gazette, vol. xiv, states that Diatom beds cover many square miles in the vicinity of active and extinct hot-spring vents, and vary from three to six feet in depth. The wagon road leading to the Geyser basins crosses several meadows of this character. Near the Emerald spring, at the Upper Geyser basin of Firehole River, there is a typical marsh of this kind, whose waters encroaching either side, have killed the pines. The larger part of the bog was sparsely covered by brackish water plants, while the drier parts are growing grass. The material in the bog is chiefly a semi-liquid, greenish gray, dirty-looking ooze, consisting, as detected under the microscope, of the shells of Diatoms of the following species, as determined by Mr. F. Wolle: *Denticula valida* (the most abundant), *D. elegans*, *Navicula major*, *N. viridis*, *Epithemia argus*, *E. Hyndmannii*, *Cocconema cymbiformis*, *Achnanthes gibberula*, *Mastigloia Smithii*, a *Fragillaria*. *D. valida*, it is stated, occurs also at the geyser basins of Iceland.

6. *Archæan limestone and other rocks in Norfolk, Connecticut.*—A large region between Winsted and Norfolk, in the western half of northern Connecticut, numbered K 2 in Percival's Report on the Geology of the State, has been supposed to be Archæan. This was the opinion of the writer after his study of the region some years since. In 1885 Mr. R. H. Cornish, then residing at Norfolk, gave the conclusion a better foundation by the discovery of limestone which had characteristic Archæan features. The village of Norfolk is ten miles to the east of Canaan where the rocks are the limestone and schists of the Taconic system. Mr. Cornish states that the limestone ledge is on the land of Mr. Ralph Crissy, near a spring southeast of his house, associated with hard gneiss, granite and some hornblendic rocks, which have in general a high eastward dip; and that it afforded him octahedrons of spinel (some of them half an inch across), together with a little chondrodite. The outcrop is only 75 yards long and 20 wide; and it was difficult to determine its stratigraphic relations to the associated rocks. Apparently it was not conformable to them; but more study is needed for a decision. In a ledge crossing Crissy Hill there is much magnetite; and two and one-half miles east of Norfolk, at the foot of Pine Mountain, and near the cross road leading from the Winsted turnpike to Grants, a large vein has been opened and was for a time worked. J. D. D.

7. *Glacial scratches in the vicinity of Norfolk, Conn.*—Mr. R. H. Cornish obtained for the direction of glacial scratches on Dutton Hill, 1640 feet high above tide level, S. 28° E., the same as on Mt. Everett, 20 miles to the west, which is 1,000 feet higher. The directions in the region, in 25 to 30 observations, varied from S. 24° E. to S. 48° E.; the mean, S. 33° E.

8. *On some Mammalian Remains of Florida and elsewhere;* by J. Leidy. Trans. Wagner Free Institute of Science, Philadel-

phia, vol. vii.—Dr. Leidy reports the discovery, by Mr. Joseph Willcox, in a crevice in Tertiary limestone, at Ocala, Marion Co., Florida, of species of Elephant, Horse, Llama, and a Saber-toothed Tiger. The last is about as large as the existing tiger of Asia, and is named *Machairodus Floridanus*. The Horse is the species *E. fraternus*, or Domestic Horse. The Llama was identified from a tooth, which is larger than the corresponding one of the recent *Auchenia Llama* of South America. The Elephant remains are probably those of *E. primigenius*.

At Peace Creek, according to collections by Mr. Willcox and Mr. T. S. Moorehead, from a sand-bar exposed at low water and explored for phosphates, remains were found of the *Tapirus Americanus* of South America; a Horse, perhaps the domestic horse; a Hippotherium, the 3-toed horse, of the species *H. ingenuum* or *H. plicatile* Leidy; *Bison Americanus*, upper molar; *Cervus Virginianus*, antlers, bones, teeth; American Elephant; a Chlamydotherium, probably *C. Humboldtii* Lund, a species found in the Brazil caverns, the specimens dermal plates; also another Brazilian Glyptodon, which is probably the *Hoplophorus euphractus* Lund, and the *Glyptodon* (*Schistopleurum*) *asper*; *Megalonyx Jeffersoni*, first phalanx; the Manatee, *Manatus antiquus*, and several Dolphins; *Emys euglypha* Leidy, a Trionyx, and a large Tortoise, *Testudo crassiscutata* Leidy; besides remains of probably the *Alligator Mississippiensis*, and of a number of fishes.

Collections of bones from the Salt Mine of Petite Anse, made by Mr. Wm. Crookes and presented in 1883 to the Smithsonian Institution, include, according to Dr. Leidy, remains of *Mastodon Americanus*, a *Mylodon*, and a Horse, the *Equus major*. A specimen of the teeth of *Equus major* is also reported from a bog on the confines of Bond and Fayette counties, Illinois.

Remains of the Quaternary Peccary, Platygonus compressus, from a gravel bank a few miles from Rochester, N. Y., were obtained by Dr. Leidy from Professor H. A. Ward, of Rochester. Other known localities of the fossil are Galena, Illinois, a cave in Kentucky, near Columbus, Ohio, in Iowa, in Benton Co., Mo., Augusta Co., Va., and Mexico. Dr. Leidy, in his article on the Platygonus, presents the details of a comparison of the skeleton with that of a Dicotyles. Dr. Leidy also states that a large species, *Platygonus vetus* Leidy, has been found in Mifflin county, Pa. Several of the species above mentioned are illustrated on plates I to VIII.

9. *Joseph Willcox on the identity of the modern Fulgur perversus with the Pliocene F. contrarius* Conrad.—In a note published by Dr. Leidy in Trans. Wagner Inst., ii, 51, Mr. Willcox points out the fact that the gradations in specimens from the Miocene to the recent form appear to prove that the former was the precursor of the latter. Mr. Willcox also shows that the non-spinose *Strombus alatus* was probably the original form of *S. pugilis*.

10. *Characteristics of Volcanoes, with Contributions of Facts and Principles from the Hawaiian Islands*, including a historical review of Hawaiian volcanic action for the past sixty-seven years, a discussion of the relations of Volcanic Islands to deep-sea topography, and a chapter on Volcanic Island Denudation, by JAMES D. DANA. 400 pp., 8vo. Illustrated by maps of the islands, a bathymetric map of the Atlantic and Pacific oceans, and views of cones, craters, a lava cascade, lava fountain, etc. New York, 1890. (Dodd, Mead & Co.)—This volume commences with a general account of volcanoes and volcanic phenomena. It illustrates the subject afterward by reviewing the facts afforded by the Hawaiian volcanoes, adding to and rearranging somewhat the descriptions and discussions that have appeared in this Journal. That the importance of the Hawaiian volcanoes to the vulcanologist may be appreciated, we mention here the special points in which they have proved to be the best known source of facts and principles,—citing from the Preface.

Science has learned, from the Hawaiian volcanoes, of volcanic activity unrestricted by altitude up to fourteen thousand feet; of the possibility of two first-class craters working simultaneously within the area of one mountain-dome, and having the loftier the more frequent and the more copious in its outflows, and neither of them ordinarily responsive to the other even when in eruption; and of the outflow of the heaviest of chrysolitic lavas at various altitudes to the very summit.

Science has learned from Hawaii more than it knew of the mobility of liquid basalt; of the consequent range in flow-angle of basalt-lavas, from the lower limit near horizontality to the verticality of a waterfall, and therefore of lava-cones of the lowest angle, and driblet-cones of all angles; of lava-lakes tossing up jets over their fiery surface like the jets of ebullition, and in other cases playing grandly in fountains hundreds of yards in height; and, consequently, of the absence from the craters of large cinder-ejections.

It has further learned of a degree of system in the changes within a crater from one epoch of eruption to a state of readiness for another; of a subsidence, after an eruptive discharge of lava, that has carried down, hundreds of feet, a large part of a crater's floor without a loss of level in its surface; and, following this, of a slow rising of the subsided floor, chiefly through the ascensive or up-thrust action of the lavas of the lava-column, and the lifting force taking advantage of the fault-planes that were made at the subsidence; and also of debris-ridges and of debris-cones, one to two hundred feet in elevation, made, by the lift, out of the talus of the pit-walls.

It has learned that pit-shaped craters are characteristic of true basalt-volcanoes, and a result of the free mobility of the lavas, whether the action in the lava-lakes within be fountain-like or boiling-like; that floating islands of solid lava may exist in the lakes; that a regular oscillation between fusion and cooling takes

place at times in the thin crust of lava-lakes; that the solid lava of the margin of a lake may be re-fused, and also even the mass of a floating island, and the blocks of a debris-cone until the cone has wholly disappeared.

It has discovered that solfataric action, or that of the hot vapors in lava-caverns, may include the recrystallizing of basalt, therein making it into long, stony pipe-stem stalactites and stalagmites, having cavities lined with transparent crystals of augite and labradorite, besides octahedrons of magnetite.

It has obtained evidence, also, that the greatest of eruptions may occur without the violence or the noise of an earthquake, and without an increase of activity in the crater; that in place of an increase there may be a sudden extinction of the fires, all light and heat and vapors disappearing as soon as the discharge begins; of the greater frequency of eruptions during the wetter season of the year; of the agency of fresh water from the rains (and snows) in the supplying of steam-power for volcanic action; of the full sufficiency of water from this source without help from the ocean—fresh water being as good as salt for all volcano purposes; and further, of a great augmentation of the activity so produced with the increase in altitude of the working crater.

These are facts from Hawaii—and not all that might be cited—that have not yet been made out from the investigation of other volcanoes, not even the best known, Vesuvius and Etna.

The work closes with a chapter of over twenty-five pages on denudation among volcanic islands in the Pacific, containing also some facts from the author's observations in Australia, taken chiefly from his Geological Report of the Wilkes Exploring Expedition published in 1849.

11. *The Geological Record for* 1880–1884; Edited by WILLIAM TOPLEY and CHARLES DAVIES SHERBORN. Vol. II, Physical and applied Geology, Petrology, Meteorites, Mineralogy, Mineral Waters, Paleontology, General Maps and Sections. 563 pp. 8vo. London, 1889 (Taylor & Francis).—This valuable volume, the contents of which are given in the title, appeared a few months since; with volume I before issued it completes the Geological Record for the five years named. The usefulness of such a work will be appreciated even by those who do not fully understand the amount of labor it has cost.

12. *Tabellarische Uebersicht der Mineralien nach ihren krystallographisch-chemischen Beziehungen geordnet* von P. GROTH, 3d edition, 168 pp. Braunschweig, 1889 (F. Vieweg & Son).—Few works upon Mineralogy have contributed so much to the progress of the science as the Tables of Professor Groth, of which the 3d edition is now issued. They present in clear and comprehensive manner the successive groups of minerals, showing the relation in composition and axial ratio of the individual species belonging to each. The author's profound knowledge and keen mind have enabled him to throw light upon many obscure points and to the advanced worker as well as to the student the Tables are constantly suggestive and helpful.

13. *New localities for Phenacite;* by W. S. YEATES (communicated).—Among a number of mineral specimens collected by me, last June, at the mica mines of Amelia C. H., Va., I have identified crystals of phenacite and topaz, the latter being altered in some instances, to the variety of muscovite known as damourite. I have one quite large pseudomorph of the damourite after topaz. The phenacite is badly cracked, and not, so far as I have seen, in good specimens. I also found galena associated with the albite. The occurrence of these minerals at this locality has not, I believe, been before announced.

I have also received from Mr. Loren B. Merrill, of Paris, Me., for identification, a flat crystal of phenacite from Hebron, Maine. It has a maximum diameter of 14^{mm} and is a combination of the planes, *O*, *i*-2, $r\frac{2}{3}$-2, $l\frac{2}{5}$-2 and a rhombohedron of the first order, too small to allow of measurement of its angles. The first mentioned plane is new to the species and a fuller description of the crystal will be published later.

14. *Hybrids in the genus Ranunculus.*—It is well known that certain genera in the Order Ranunculaceæ contain doubtful natural hybrids, while in a few genera of the Order, this tendency to hybridize has been utilized for the production of some of the most attractive plants in general cultivation. FREYN has lately given, in the Botanisches Centralblatt, (1890, 1–6), an interesting account of certain species of Ranunculus, in which, after referring to the investigations of others, he describes a few possible hybrids. *Ranunculus lacerus*, *Bellardi*, has been regarded as the offspring of *R. aconitifolius* and *R. Pyrenæus*, or more probably, of the former with *R. plantagineus*. But from his researches Freyn concludes that this is not a true hybrid: it is more probably a vigorous form of *R. plantagineus*.

The supposed cross between the two species *R. arvensis* and *R. bulbosus* is reduced by him to a variety of *R. bulbosus* with much divided leaves, the divisions however, falling within the range of form found in *R. bulbosus*.

In the same way, the author reduces the so-called hybrid of *R. bulbosus* and *montanus*, in Heer's Herbarium, to *R. mixtus*. He says that he cannot consider it a hybrid, much less a hybrid in which *R. bulbosus* has had any share.

Certain forms have been described as resulting from the crossing of *R. bulbosus* and *R. nemorosus*. All of the supposed hybrids are brought by the author down to varieties of the species named, or to *R. montanus*, but he recognizes no true hybrids in any of the forms.

The supposed hybrid between *R. bulbosus* and *R. polyanthemos* fares a little better. One from the northern limit of *R. bulbosus*, was described by Schmalhausen (in which the parents as given above are reversed in order) and this is thought to be a hybrid, but a second, described by Lasch, is thrown out.

The plant which has been described as a hybrid of *R. bulbosus* and *R. repens*, is regarded as a form of *R. Philonotis* Ehrh., a synonym of *R. Sardous* Cz.

In the same manner the author is compelled to state that the supposed cross of *R. lanuginosus* and *montanus*, if indeed a hybrid at all, is more likely a hybrid between *nemorosus* and *Villarsii*, or between *nemorosus* and *montanus*.

R. lanuginosus and *nemorosus* hybrids turn out to be merely forms of *R. nemorosus*. The criteria employed by the author are not merely found in the features of the plant, but also in the geographical range of the alleged parents; and by an application of his method, the number of Ranunculus hybrids has been materially reduced.

Attention has been called to this short but interesting communication in the hope that our local botanists will scrutinize the so-called hybrids not only in this but in allied genera with greater care than heretofore, relying not only upon apparent marks of resemblance but giving due weight to the characters drawn from impaired fertility, and from the circumstantial evidence which comes from an examination of the habitat of the supposed parents. G. L. G.

15. *Corals and Coral Islands;* by JAMES D. DANA. 440 pp. 8vo. New York, 1890 (Dodd, Mead & Co.).—A new edition of this work is just now leaving the press. It contains much new matter on the subject, and, in the course of it, a full discussion of the Darwinian and opposing theories of coral reefs. It is illustrated by several new plates and maps, four of the plates being colored plates of corals from the author's Exploring Expedition Report on Zoöphytes, published in 1846.

OBITUARY.

EUGÈNE E. DESLONGCHAMPS of Chateau Mathieu, Caen, formerly Professor of Zoology and Paleontology at the Faculty of Sciences, Caen, Calvados, died in December last. He was the son of the celebrated French paleontologist M. Eudes-Deslongchamps, and had published extensively on paleontological subjects, including a Prodromus of the Teleosaurians of Calvados and "Les Brachiopodes Jurassiques de la France." His "Études critiques sur des Brachiopodes nouveaux ou peu connus," and "Le Jura Normand" were in course of serial publication.

Dr. MELCHIOR NEUMAYR, Professor of Paleontology in the University of Vienna, died on the 29th of January at the age of forty-four. He was one of the ablest and most active of the corps of Austrian geologists, and had written many important memoirs on Paleontology; his early death is a great loss to science.

Dr. VICTOR RITTER VON ZEPHAROVICH, Professor of Mineralogy at Prague, and author of numerous papers, chiefly on crystallographic subjects, died on the 24th of February in his 60th year.

Dr. F. VON QUENSTEDT, the veteran paleontologist and mineralogist of Tübingen, died December last. He was the author of important works on Paleontology, Mineralogy and Crystallography.

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